Clyde Hubbard's Upside-Down Monclova Mint Stamp on a GNL Eight Reale Class 1 (Pre-1830) Contemporary Circulating Counterfeit. Determining if Die Struck or Cast and its Period of Production Using a Triple -Tier SEM/EDS Analytical Approach.

Introduction

During a Briggs/Bustos auction involving counterfeits both of a contemporary (i.e., of the period) and of later periods an interesting upside-down 1812 Monclova mint stamp used *possibly* during the Mexican War of Independence (WOI) period on an 8 Reale host appeared in their auction catalog. The auction catalog description was as follows: Countermark MVA/1812. Modern manufacture, distinguishable by its sharp edges and the framing around the date protruding to the right compared to the one framing the initials MVA, placed on the obverse of an authentic 8 Reales 1811 Mo HJ coin with an armored bust. An absurdity considering that the limitations of the Monclova Mint were such that only 8 Reales coins were cast and validated through countermarks. Countermark is in AU grade, host in XF with minimal marks and lines, dark patina on design edges. Metallic composition via an XRF analysis: Ag (89.81%), Cu (9.89%), Pb (0.19%) & Bi (0.1%). Includes a spectrometry certificate and a flip with a purchase value of US$250.00. Ex. Clyde Hubbard Collection. Further investigation by this author revealed the host coin based on its motifs matched a pre-1830 period Class 1 GNL (1) Variety: GNL#1811-O: G/R: Mo HJ-001 on page 414 of the GNL book. So, this piece did take on a new *fresh* outlook with this so-called counterfeit mint stamp due to an initial observation that a stop was not present after MVA, but a stop was present after 1812, and the cartouche sizes were different. Figures 1 & 2 below shows the specimen in the auction (obverse and reverse respectively) and Figure 3 shows a side-by-side comparison of a real Monclova stamp vs. a falsa (i.e., false) mint stamp based on current research primarily by Max Keech in MNA Journals.

Figure 1: Obverse of the Briggs/Bustos 1811 Monclova Counterfeit with the Monclova mint stamp upside down. No stop after MVA and the cartouche sizes are different with the MVA stamp being slightly smaller than the 1812 date cartouche on a GNL#1811-O: G/R: Mo HJ-001 host. As with a genuine Monclova mint stamp this stamp appears to be of a "singular" construction mint stamp.

Figure 2: Reverse of the Briggs & Bustos 1811 Counterfeit. Host coin appears struck and to be verified by SEM/EDS analysis. Metrology: 39.78 mm and 26.87 grams. A counterfeit type of edge.

Figure 3: Cross-comparison of the so-called false mint stamp on the left and a genuine mint stamp on the right primarily based on the stops after MVA and the 1812 date. In this case the specimen in the auction is lacking a stop after MVA creating the idea its counterfeit. MVA cartouche is smaller than the 1812 cartouche but as with the regal mint stamps it's of a "singular" stamp construction.

For background purposes Max Keech (2) on page 17 in his article in the U.S. Mexican Numismatic Association December 2014 Journal describes the Monclova mint produced cast coins using only Mexico City hosts produced from actual struck *mother coins* to produce the casting molds and then applying a mint casting stamp with the initials "MVA" and date (1811 or 1812) to the finished cast coin product. Krause catalogs the issue as a counterstamp even though it's a mint issue with a mint casting stamp applied before the coinage entered circulation. The issue always has a plain edge with no rectangular/circled regal type edging. Keech continues to add: After 1814 the Monclova issues were recalled and often used as planchets for striking coins in Chihuahua. So, any post 1812 issues showing MVA stamps that are overstruck on Monclova hosts as KM#201 which miscatalogs overstrikes as Chihuahua's with a Monclova counterstamp needs deletion from the KM Standard Catalog of World Coins of the1801-1900 Edition. From this MNA Journal we have some further guidelines on how to determine a genuine Monclova mint stamp issue from a contemporary counterfeit or a later issued mint-stamp outside the War of Independence Period:

- All validation (mint) stamps were used either as casting stamps or counterstamps apart from Morelos, never for both and in this case, Monclova being a casting stamp made during a production period of 1811-1812. Mint stamp was applied to the cast coin while still hot.
- All validation stamps during the WOI were applied between 1811 and 1814 and in this case no Monclova should appear on a cast host coin after 1812 and be only of a Mexican City mint.
- Only provisional/necessity coinage was countertamped.
- In review of all genuine Monclova validation stamps in auction archives the coins have a stop (i.e., period) after both MVA and either one of two possible dates - 1811 or 1812.

So, for this example we have an unusual upside-down applied mint stamp. There is no stop after MVA as seen in Figure 1. It's also required both the MVA and date cartouche areas should be of "equal size." The host coin is a GNL Class 1 (pre-1830) Contemporary Circulating Counterfeit with a variety # of GNL #1811-O: G/R: Mo HJ-001. If we look at page 414 in GNL we see Gurney's unique specimen at the time in 2014 and it's interesting to note was a cast specimen. The author has recently added this variety to his collection but as with most GNL varieties, just because Gurney's piece is cast the second, third or other subsequent discoveries of this or any GNL variety can be of another alloy type and can be found either struck or cast. So, the fact that Gurney's piece is cast and meets the qualification for a Monclova stamp to be on a cast coin prior to no later than1812 is interesting, but it still requires a complete SEM/EDS analysis on the Briggs & Bustos piece to determine if its cast or die struck in its microstructure. Since the picture of this Gurney variety is poor in the GNL Reference Book the author has a slightly better photo in his photo archives acquired from Gurney in 2014. These archived photos are currently sold on EBay as a 2-CD pack to accompany the GNL book; we still however will supply below in Figures 4 and 5 the obverse and reverse images of the author's struck piece. This is so the reader can compare Figures 1 and 2 with a clearer struck example of this variety to confirm this host coin is a pre-1830 GNL Class 1 contemporary counterfeit of the period. The author's coin appears to be mercuric silvering over a copper die struck host, but a future XRF analysis will confirm this suspicion which is outside the scope of this project since it's not cast. The author's struck piece also has a crude edge and has all the diagnostics of this variety. These major diagnostics are we see the last '1' in the date taller than the previous three numerals on the obverse and on the reverse, we see a right tilting 'S' and 'PAN' is aligned *above* this tilting 'S' within 'HIS' which are all on the same alignment. So, the 'HIS' letter grouping is below the 'PAN' letter grouping on two different alignments. This occurrence of a Monclova stamp on a Class 1 GNL CCC variety is not unique as on page 406 in GNL we see the GNL variety: GNL#1809-O: H/R: Mo TH-005 but in this case the 1811 Monclova stamp MVA/1811 are *inverted* and with all so-called genuine Monclova mint stamps the date is normally below MVA. In this case, although *we do see stops* after MVA and the 1811 date being the other possible date for a Monclova mint stamp this is a falsa stamp. The author also has this variety and it appears as a cast silver planchet. The author is proposing a Sampling Methodology using a previously developed SEM/EDS Triple Tier Analysis (3) on these coins to investigate the likelihood this mint stamp is of the period. A metal assay, microstructure and Point & ID analysis on this coin can help us get a better handle of what the metallic fabric is on this *unusual* Clyde Hubbard Monclova 1812 piece (Figures 1 & 2).

Since SEM/EDS allows us to determine if a coin is cast or die struck, a confirmation of a surface metal assay of all the elements on the so-called *outer corrosion layer* and comparing these results to three other genuine Monclova pieces will assist us better in understanding this Hubbard oddity.

Figure 4 – Obverse of GNL#1811-O: G/R: Mo HJ-001. Note the last numeral '1' higher than the previous three numerals as a major obverse die diagnostic of this variety. Identical obverse die to the Briggs & Bustos Monclova counterfeit piece in their catalog. Refer to Figure 1 for comparison. This piece is a struck specimen. Pictured here solely to confirm the host coin on the Briggs & Bustos Hubbard piece is a contemporary counterfeit of the general period (i.e., ~pre-1830).

Figure 5 – Reverse of GNL#1811-O: G/R: Mo HJ-001. Note the tilting 'S' in HISPAN. 'HIS' is below the 'PAN' alignment. Same reverse die as the Briggs & Bustos specimen. Refer to Figure 2. The coin in hand appears as a high copper host with silver wash. On the reverse the copper core area being clearly exposed and only the outer areas currently have mercuric silvering, giving this visual bulls-eye effect. Not cast but considered a counterfeit die variety that *possibly* circulated within the same period of 1810-1812 during the production period of the Monclova issues.

The same obverse/reverse dies as the Briggs & Bustos piece and what is also interesting this reverse die of this 1811 GNL contemporary counterfeit is "identical" to an 1809 dated cast host for a *genuine* 1811 Monclova piece – See Stacks/Bowers 10/29/2024 – Lot 72541.

Sampling Methodology/Strategy

The goal of this paper is to use SEM/EDS analysis to analyze both the Briggs & Bustos specimen beyond the surface semi-quantitative XRF analysis and to also examine in the author's collection three confirmed Monclova 1811 and 1812 issues. This along with a probable cast silver GNL Class 1 Variety of the same variety as with Gurney's piece that had the Monclova inversion stamp: GNL#1809-O: H/R: Mo TH-005. So, the sampling scheme will involve the following five coins where Specimen #1 will get duplicate target point analyses and Specimens #2-#5 single surface target points. So, the sampling methodology involves:

1. **Specimen #1**: Briggs & Bustos coin depicted in Figures 1 & 2. Determine if dendritic cast or twin line (grain) die struck based on its microstructure micrograph. Also use Point & ID analysis to examine the different light/dark colored areas of its microstructure to view the different metal regions. Perform a duplicate analysis and this is typically done with debased silver alloys with copper, die struck bi-layer Sheffield Plated over copper alloy issues or mercuric silver over copper issues. **Duplicate Analysis. Two Surface Target SEM/EDS Points.**
2. **Specimen #2**: GNL #1809-O:H/R: MoTH-005 Class 1 GNL contemporary circulating counterfeit 8 Reale the same die variety as the Gurney piece having the inverted Monclova stamp (GNL - page 406). The author's specimen appears as a cast silver coin based on its fabric and has a lower coin ring than a 90% U.S. Silver dollar. What does its microstructure look like compared to a genuine cast silver Monclova mint stamp piece of this same period? An analysis simply being done for more exploratory information. See Figures 6 & 7. Metrology: 39.7mm, 25.77 grams (low weight to regal), Dotted Edge/Crude. **Single Surface Target SEM/EDS Point.**
3. **Specimen #3**: Genuine 1811 Monclova specimen with an MVA/1811 mint stamp and with a later LCM validation stamp. Host coin being an 1804 Mo TH Assayer specimen. Metrology: 40.36mm, 26.9 grams, Plain Edge with crude file markings around 360*. See Figures 8 & 9. *Ex. Chris Stevens*. **Single Target SEM/EDS Point.**
4. **Specimen #4**: Genuine 1811 Monclova specimen with MVA/1811 mint stamp. Host coin an 1810 Mo TH Assayer. Metrology: 40.85mm, 26.4 grams, Plain Edge with crude file markings 360* around. See Figures 10 & 11. *Ex. Aureo & Calico*. **Single Surface Target SEM/EDS Point.**
5. **Specimen #5**: Genuine 1812 Monclova specimen with MVA/1812 mint stamp. Host coin dated 1812 Mo TH Assayer. Metrology: 41.3mm, 27.94 grams, Plain Edge with crude file markings 360* around. *Ex. Mexican Coin Company*. See Figures 12 & 13. A high-end benchtop EDAX Orbis XRF Vacuum Analyzer provided this metal assay: Ag (92.26%), Cu (6.76%), Fe (0.08%), Co (0.24%), Ni (0.04%), Zn (0.05%), Pt (0.19%), Au (0.18%), Hg (0.07%), As (0.09%) and Bi (0.05%). This semi-quantitative XRF surface analysis on the corrosion layer of the surface does demonstrate it to be a period

piece with high silver (92.26%) and its slightly elevated Ag level due to the silver surface enrichment effect, with trace gold and platinum at expected levels (~0.1-1.5%). The iron, nickel and zinc are probable ore contaminants. Mercury at trace level is probably from the amalgamation of the silver ore process and arsenic and bismuth are also probable ore contamination sourced metals. **Single Surface Target SEM/EDS Point.**

6. **Specimen #6**: Robert Gurney's MVA/1812 Inverted specimen pictured in GNL (1). **Analysis unable to be performed at this time. See Figure 15.**
7. **Specimen #7**: Robert Gurney suspected 1812 Monclova specimen which mimics the Pradeau plate coin in its MVA/1812 motifs and is on a similar Mexico City mother coin produced cast coin. **Analysis unable to be performed at this time. See Figure 16.**

Figure 6 – Obverse of the GNL#1809-O:H/R: Mo TH-005. Same GNL variety with the inverted Monclova stamp. Gurney specimen. However, this alloy type appears visually as a cast silver alloy. Note the mushy surfaces/portrait and the noticeable filled-in '8' in the date. Gurney's host coin is either a debased silver alloy or silver wash over a base alloy such as copper and is not cast. See page 406 in GNL. See Figure 15. Why the SEM/EDS analysis? Comparing a cast silver GNL Class 1 counterfeit to a group of cast regal Monclova specimens (i.e., Specimens #3-#5) for comparative reasons and see if there are any similarities and differences in their microstructure for a binary alloy (Ag/Cu) system.

Figure 7 – Reverse of the GNL# 1809-O"H/R: MoTH-005. Specimen #2 in the sampling methodology scheme. Again, the main reason to include this piece in the Sampling Methodology is it will be interesting to review a possible cast silver period Class 1 Contemporary Circulating Counterfeit of the same general period (i.e., ~pre-1830 for Class 1 Counterfeits) and if proven to be cast silver compare its microstructure and metal assay to several genuine cast silver Monclova Cast Silver pieces. This will be discussed more in the Analytical Methodology section which describes what advantages SEM/EDS surface analysis have over XRF surface analysis. There was no point in analyzing the author's 1811 piece (Figures 4 & 5 above) since the piece is a silver wash type over a die struck copper host. This probable cast piece being more noteworthy/informative for our purposes here in this investigation of cast Monclova specimens.

Figure 8 – Specimen #3. Obverse of the 1804 host 1811 Monclova mint stamp with an LCM stamp which reads from K-2 to K-7 as L.C.M. and was applied later (i.e., over the Monclova mint stamp). My records on this piece indicate there are ~18 different LCM types and this L.C.M. stamp based on its motifs and vertical/horizontal micrometer measurements is identical to a L.C.M. Two Reale Zacatecas-LVO in Pradeau Plate XIX #8 (4). Stops appear after MVA and 1811. A rim imperfection from the casting mold operation is seen at K-10/11. Both the MVA and 1811 cartouches are of equal size – as required. Ex. Chris Stevens, Florida.

Figure 9 – Specimen #3. Reverse of the 1804 host Monclova 1811 mint stamp with an LCM later applied validation stamp. Cast silver. For identical MVA/1811 mint stamps with a higher left 'V' and thin '8' in 1811 see both Stacks August ANA 2017 – Lot 22789 & Stacks 1/8/2013 Lot 1545 for identical MVA letter punches and 1811 numeral punches for validation purposes and accuracy.

Figure 10 - Specimen #4. Obverse of the 1810 host with a Monclova 1812 mint stamp. Cast Silver. Ex. Aureo & Calico. Previously Marti Hervera of Spain. Similar MVA 1812 Monclova mint stamp to Stacks/Bowers November 2012 Auction, Lot 11139 specimen from my notes on the coin's flip ticket and mentioned solely for cross-comparison validation purposes.

Figure 11 – Specimen #4. Reverse of the 1810 host with a Monclova 1812 mint stamp.

Figure 12 – Specimen #5. Obverse of the 1806 host with a Monclova 1812 mint stamp. This specimen as previously described had good silver and trace gold levels from a previous XRF analysis. In the forthcoming SEM/EDS we will verify its good silver content and view its microstructure to confirm it's of a dendritic (cast) microstructure utilizing SEM/EDS analysis. Ex. Mexican Coin Company.

Figure 13 – Specimen #5. Reverse of the cast silver 1806 host with a Monclova 1812 mint stamp. As with the previous Monclova reference sample pieces in this study all are of a good silver weight, have stops after both MVA and dates (1811 or 1812) and are on proper dated hosts with cast silver planchets and have plain edges with crude diagonal hand markings. None have circled/rectangular type regal edging as is required as part of their authenticity criteria. The author has not investigated if some Monclova pieces may have edges with no markings, not even crude diagonal markings which appear in all these three Monclova specimens. These are considered Plain Edges as compared to the conventional circle/rectangle edging as seen on the 1811-1813 Cast Chihuahua pieces. However, on a rare occasion some Chihuahua specimens appear as Plain Edge and are missing this step of having an applied regal type of edge as the author has seen several and currently has one in his collection. This fact has been discussed already with the noted collector Mike Dunnigan in the past.

The Analysis on Clyde Hubbard's Upside-Down Monclova's Mint Stamp Specimen

The Clyde Hubbard specimen is indeed unusual. We have a possible genuine Monclova 1812 mint stamped upside down whereas the rest of the Monclova mint stamps are stamped upright and centered. The fact that it was stamped upside down may possibly mean it was a test piece. The three main points putting it outside the realm of other Monclova mint stamps is lack of a stop after MVA, the different sizes of the cartouches for MVA & 1812 which as with other Monclova mint stamps "need" to be of equal size. It appears on a struck piece and not a cast host. See Figure 14 as the second surface target point being performed. This target point will give us a good idea on what the "underlayer" may look like if a Sheffield Plate bilayer coin (i.e., silver plate over a copper alloy type host) or is the host coin homogenous as in a debased silver alloy with copper for a Class 1 GNL contemporary circulating counterfeit.

Figure 14. A second target point (red dot area) deep within the dated 1812 cartouche area will be performed. This is suspected to be the underlayer base alloy as compared to the top silver layer whether silver plated, mercuric silvered wash in a bi-layer contemporary counterfeit or simply a debased silver alloy with copper. Silver plating and mercuric silvered area vary in their depth. Mercuric silvering, also known as fire gilding, typically involves applying a very thin layer of silver to a base metal. The depth of the silver layer can vary, but it is generally in the range of *microns*—often less than 10 microns. This technique was historically used for decorative purposes, but it is hazardous due to mercury's toxicity. Sheffield plating, on the other hand, is a process where a thin sheet of silver is fused to a base metal, such as copper. The silver layer in Sheffield plating is usually thicker than that of mercuric silvering, often ranging from *0.1 to 0.5 millimeters*, depending on the quality and purpose of the item. SEM/EDS Analysis did not show any differences and the SEM microstructure was identical to the first random target point so only the initial target point results are being reported in this study. Additionally mint stamping in this area would produce more workability or further deformations to the SEM microstructure so it's had little extra value in this coin's microstructure analysis. This is explained further in this paper on dendritic deformation causes such as areas of high workability such as mint stamp areas (i.e., MVA/1812 stamp).

Analytical Methodology

SEM/EDS is preferred over XRF in several specific applications where high-resolution imaging and detailed elemental analysis are required. Here are some of the key applications:

Materials Science and Engineering:

- **Microstructure Analysis**: SEM/EDS is used to study the microstructure of materials, including grain boundaries, phases, and defects. This is the main reason for doing this study on these five specimens. With nearly 100% certainty we will confirm the dendritic cast or die twin grain struck profile of the Briggs & Bustos piece (Specimen #1) with confirmed dendritic silver cast microstructures of the Monclova Specimen's #3 - #5.

- **Composition Mapping**: It provides detailed maps of the elemental composition, helping in understanding the distribution of elements in complex materials. This will allow to view for the first time the dendritic microstructure of genuine cast silver Monclova specimens of the War of Independence issues in Mexico during this early period of 1811-1812.

- **Phase Identification**: SEM/EDS is used to identify different phases in metallic alloys. This will allow us to see in some ways the fingerprint microstructures of genuine Monclova pieces and review if their cast dendritic microstructures are all similar. **Normally the same type of manufacturing operation should produce similar microstructure profiles.**

- **Corrosion Analysis**: It helps in studying the corrosion mechanisms and products on metal surfaces. In other words, surface contaminants like chlorine and sulfur can be identified as well as trace metals such as gold and platinum. Which trace metals are part of the alloy and which metals are considered outside contaminants or foreign in the metal assay like sulfur and chlorine, two of the most common contaminants seen on the surface or corrosion layer of any coin. SEM/EDS can detect these lighter elements.

Overall, SEM/EDS is preferred in applications where detailed imaging and precise elemental analysis of small areas are essential. Its ability to provide high-resolution images and localized elemental information makes it a powerful tool in various fields of research and industry. SEM/EDS works as follows:

- **SEM Imaging**: The scanning electron microscope generates a beam of electrons from an emitter-cathode within an electron gun. This beam is accelerated and focused by an anode and a series of electromagnetic lenses. It is then scanned across the surface of the sample, interacting with the atoms in the sample and causing secondary electrons to be emitted from the surface. These emitted electrons are collected to create detailed images of the sample's surface.
- **EDS Detection**: When the electron beam strikes the specimen surface, it causes the emission of X-rays. Each element in the sample emits X-rays with unique energy levels. The EDS detector measures the energy of these X-rays to determine the chemical composition of the sample. This allows for the identification and quantification of elements present in the sample.
- **Applications**: SEM/EDS is widely used in materials science for applications such as product failure investigation, contaminant identification, and detailed particle classification. It provides high-resolution chemical composition maps and helps researchers understand processes occurring within a material.

The author is sending these samples to an independent third-party laboratory at the Michigan State University Research Technology Support Facility in East Lansing, Michigan. This author has worked with this Laboratory before on a similar three tier SEM/EDS type of analyses (3). The results of this section will be for the examination of a random target area chosen by MSU of unpolished/edge polished areas of each specimen # 1-5 described above. Initially an EDS metal assay by weight percentages is calculated on what is called a Map Sum Spectrum.

This is followed by a SEM Micrograph Microstructure of the same area under a chosen specific magnification level to determine if the coin’s microstructure is cast dendritic or twin (grain) line - die struck. Finally, a Point & ID SEM Micrograph is performed showing the different Black and White (B&W)

shaded areas of the selected SEM Photomicrograph (micrograph term is also acceptable) and what metal or metal areas these spectrum areas constitute. In other words, the SEM/EDS apparatus in this case can target different Black & White (B&W) shaded regions of the SEM micrograph (i.e., microstructure area) and then determine which metals appear in these areas and these are classified as spectrum areas. Each area is numbered, and the associated metal assay results are displayed for each spectrum area. This three-part reporting scheme will become clearer once the results are presented. The reader at this point may wish to review the Glossary of Definitions at the end of this paper prior to reviewing the Results section to help him interpret the results more clearly by understanding the scientific terminology used in this section.

Figure 15. Specimen #6. Unusual MVA and Date "inversion piece" like the Briggs & Bustos Hubbard specimen solely on the fact the host coin is also a GNL Class 1 Contemporary Circulating Counterfeit – in this case GNL# 1809-O: Hc/R: Mo TH-005. Plated on page 406 in the GNL Reference Book but of course on a different GNL variety. Unable to be analyzed but noteworthy.

Figure 16. Specimen # 7 A possible genuine Gurney Monclova piece with near identical MVA & 1812 motifs to the Pradeau Plate Coin #8 Plate XIX in his standard reference book (4). See Figure 17 for the Pradeau Plate Coin. Currently the Pradeau piece its pedigree is unknown and therefore no reverse photo is available although confirmed in the cataloging of Pradeau's collection as a Mo HI reverse. Unable to be analyzed but noteworthy. Gurney considers this piece to be fake as he believes the dies from his database suggest a later striking. This author disagrees with this analysis and considers this piece genuine and of the period. Unable to be analyzed but noteworthy.

Figure 17. Pradeau plate coin #6 illustrates the identical features in the obverse to the Gurney specimen pictured in Figure 16 therefore worthy of an SEM/EDS analysis to confirm its cast silver properties and its comparison to other genuine Monclova pieces in this study.

Results

Initially an EDS metal assay by weight percentages is calculated on what is called a Map Sum Spectrum. This is followed by a SEM Micrograph Microstructure of the same area under a chosen specific magnification level to determine if the coin's microstructure is cast dendritic or twin (grain) line - die struck. Finally, a Point & ID SEM Micrograph is performed showing the different Black and White (B&W) shaded areas of the selected SEM Micrograph and what metal or metal areas these spectrum areas constitute. In other words, the SEM/EDS apparatus in this case can target different B&W shaded regions of the SEM micrograph (i.e., microstructure area) and then determine which metals appear in these areas and these are classified as spectrum areas. Each area is numbered, and the associated metal assay results are displayed for each spectrum area. The author will provide comments for each of the three tiers: Map Sum Spectrum, Microstructure-Micrograph and Point & ID Spectrum for each Target Point of the five specimens.

Cast sterling silver exhibit dendritic microstructures, which are tree-like patterns formed during the solidification process. Here's a closer look at their appearance and formation:

Appearance

- Tree-like Patterns: Dendrites resemble branching trees or coral structures, with a central "trunk" and smaller "branches" extending outward.
- Contrast in Composition: In sterling silver (an alloy of 92.5% silver and copper), the dendritic regions may show variations in composition, such as silver-rich and copper-rich areas, which can appear as alternating light and dark regions under a microscope.

Formation

- Solidification Process: Dendrites form when the molten alloy begins to solidify. The process starts with nucleation, where small solid particles form in the liquid metal.
- Growth in Preferred Directions: As the solid particles grow, they extend along specific crystallographic directions, creating the characteristic branching structure.
- Cooling Rate: The size and spacing of the dendrites depend on the cooling rate. Faster cooling leads to finer dendrites, while slower cooling results in coarser structures.
- Segregation: During solidification, elements like copper may segregate to specific regions, influencing the final microstructure.

These dendritic structures play a crucial role in determining the mechanical and aesthetic properties of cast sterling silver. In this study we have cast dendritic microstructures like the three regal Monclova pieces. We can consider these as control standards of cast silver specimens (Specimens #3, # 4 & 5). We will proceed through each specimen from #1-#5 and explain their metal assays and microstructure properties in detail.

As part of the preliminary investigation, it was investigated if these coins particularly specimens #3-#5 due to their monetary value could be analyzed without any surface edge polishing?

Unfortunately, the answer was basically “no” for several reasons:

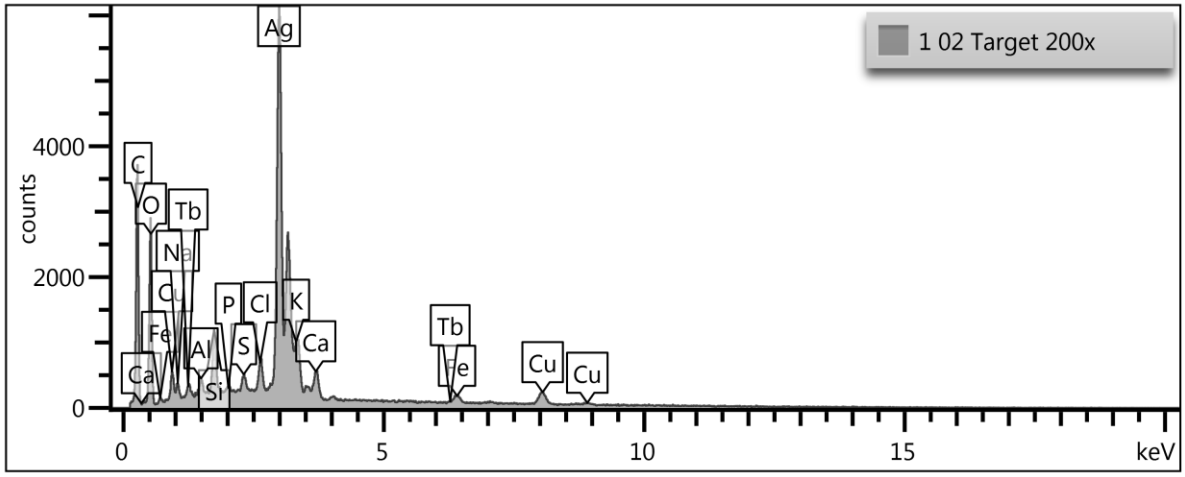
1. **Eliminating Surface Roughness** – A rough surface can scatter electrons unpredictably, leading to distorted or unclear images. Polishing therefore smooths out imperfections to ensure accurate imaging.
2. **Removing Debris & Contaminants** – Any loose particles, oxidation, or dirt on the surface can interfere with analysis, affecting the clarity and accuracy of results.
3. **Enhancing Electron Interaction** – SEM relies on electron interactions with the sample. A polished surface allows electrons to reflect more consistently, improving contrast and detail.
4. **Optimizing Edge Definition** – Sharp microstructural features, such as grain boundaries or phase distributions, can be obscured by an uneven surface. Polishing makes these features more visible.
5. **Minimizing Charging Effects** – In non-conductive materials, surface roughness can lead to uneven charge distribution, causing imaging artifacts. Polishing helps distribute the charge uniformly.

The average area and depth for SEM/EDS analysis can vary depending on the sample and the settings used. However, here are some general guidelines:

- **Analysis Area**: In SEM, the analysis volume typically ranges from **0.1 to 3 microns**. For STEM (Scanning Transmission Electron Microscopy), the spatial resolution can be as small as **1 nanometer**.
- **Analysis Depth**: The depth of analysis depends on the acceleration voltage and the material's density. In SEM, the sampling depth usually falls between **0.1 to 3 microns**. For EDS analysis, the depth can range from **1 to 5 microns**, depending on the matrix and acceleration voltage.

These values can change based on the specific SEM/EDS setup, beam energy, and sample composition. So, with such small area values as XRF analysis which surface scans encompass a larger area and more penetration depth, the area scan is in millimeters and its depth of range for lighter elements is 25 um to 4 mm. However, in this project with SEM/EDS we can look at all the lighter elements below sodium such as chlorine and sulfur and look at the coin’s microstructure whether cast or struck. We did some preliminary analysis on the coins (specimens #1-#5) and the effects of not removing the corrosion layer on the coins (i.e., no polishing). The thickness of a ~200-year-old corrosion layer on a typical 90%Ag/5-7% Cu alloy coin can vary depending on environmental conditions, exposure to moisture, and chemical interactions. However, studies suggest that the corrosion layer on such coins is typically ~25 microns thick (minimally).

Over time, silver tends to enrich the surface, but also the overall silver content can decline due to corrosion and environmental exposure. For example, older coins with ~90% silver content may drop to around ~80% silver due to prolonged oxidation and surface reactions. Factors such as soil composition, humidity, and pollutants can influence the corrosion rate. To confirm this aspect MSU did some surface scans on these specimens unpolished. An example follows in Figure 18.



Element	Line Type	Apparent Concentration	k Ratio	Wt%	Wt% Sigma	Standard Label	Factory Standard
C	K series	1.54	0.01540	20.72	0.41	C Vit	Yes
O	K series	2.17	0.00729	28.28	0.33	SiO2	Yes
Na	K series	0.09	0.00040	0.79	0.07	Albite	Yes
Al	K series	0.06	0.00041	0.45	0.04	Al2O3	Yes
Si	K series	0.26	0.00203	1.74	0.05	SiO2	Yes
P	K series	0.04	0.00023	0.18	0.03	GaP	Yes
S	K series	0.09	0.00074	0.50	0.04	FeS2	Yes
Cl	K series	0.12	0.00105	0.69	0.04	NaCl	Yes
K	K series	0.22	0.00183	1.13	0.07	KBr	Yes
Ca	K series	0.24	0.00217	1.58	0.06	Wollastonite	Yes
Fe	K series	0.17	0.00170	1.14	0.09	Fe	Yes
Cu	K series	0.47	0.00472	3.18	0.14	Cu	Yes
Ag	L series	5.93	0.05934	39.39	0.32	Ag	Yes
Tb	L series	0.03	0.00029	0.23	0.19	Tb (v)	Yes
Total:				100.00			

Figure 18: Map Sum Summary of Specimen #1 - Briggs & Bustos Specimen. Due to the unpolished surface of the coin's corrosion layer as discussed previously can equal ~25 microns minimally or more. Coupled with the low depth of the beam penetration of the SEM/EDS device (i.e., 0.1-5 microns) it's not penetrating the actual original surface when the coin was first produced. The irregular contaminated surface corrosion layer reveals the obvious outcome. Metals such as Na, Al, P, K, Ca and Tb are obvious surface contaminants along with typically seen S & CL which are environmental contaminants. These metals form carbonate compounds yielding this high carbon value (C: 20.72%) and very high oxide results as seen in this high oxygen value (O:28.28%) indirectly dropping the Ag value to ~40%. Some target points were not so dirty, which revealed Ag near 80% and not even achieving the desired near 90%Ag expected for these Monclova standard specimens #3-#5. It was therefore required to polish the third side (i.e., edge of the coins) in an area to be less obtrusive as possible with these valuable numismatic artifacts.

For one last confirmation of the need to polish numismatic examples prior to SEM/EDS analysis we will look at a Point & ID Analysis of a genuine Monclova specimen in this case Specimen #5 in this study. This will be worthwhile to educate future numismatists wanting to explore this method for authenticity and confirmation of numismatic examples in their collection were polishing a small area of the edge (i.e., very unobtrusive) is required for more worthwhile and accurate results. As seen in the Glossary Point and ID Analysis of a SEM Microstructure Micrograph (i.e., SEM Image at a particular magnification – in this case 1000X) refers to a technique used to identify and analyze specific points within a microstructure image. This process typically involves Energy Dispersive X-ray Spectroscopy (EDS), which allows for elemental composition analysis at precise locations on the sample.

How It Works:

1. **Point Selection** – A specific point on the SEM image is chosen for analysis.
2. **X-ray Detection** – The SEM is equipped with an EDS detector that collects X-ray signals emitted from the sample.
3. **Elemental Identification** – The detected X-rays are analyzed to determine the elemental composition of the selected point.
4. **Data Interpretation** – The results help in understanding material properties, contamination sources, or structural characteristics.

This method is widely used in *material science, failure analysis, and quality control* to gain insights into the composition and characteristics of microscopic structures. In Figure 19 below the Monclova on the 1806 host coin from the Mexican Coin Company (Specimen #5) a singular random target point was chosen to produce a SEM Microstructure micrograph. Within the microstructure micrograph *four* different color shaded areas were observed by the MSU analyst and chosen to perform different metal assays on these different black and white colored/shaded regions. This is being illustrated to show another example of the importance of polishing and cleaning a region desired for SEM/EDS analysis to be performed. This is the third tier of the three-tier method which involves a Map Sum Summary/Microstructure/Point & ID analysis of the different regions within this microstructure. In this case four regions or four spectrum areas were isolated, and this is seen in Figure 19. With ~90% Ag/~5-7% Cu metal assay coins copper is added to give the alloy durability and workability. The other metals normally seen are tin, lead and zinc due to the refining process and natural impurities in the silver ore. At times, depending on the silver source trace gold is seen normally below 1.5% but, in this study, and due to the single target areas gold may not be detected as values below 0.1% are not detected by this instrument based on its set detection limit. So having said all this we can see clearly some of these sample spectrum areas in Figures 19-c&d (i.e., Spectrum areas #3 & #4) yielded a lot of so-called surface garbage (i.e., environmental contaminants) not inherent in the original coin when it was first produced. Again, the author is only emphasizing the need to polish the area prior to analysis and choosing the edge which is the least obtrusive area to perform such a task on any expensive numismatic historical artifact.

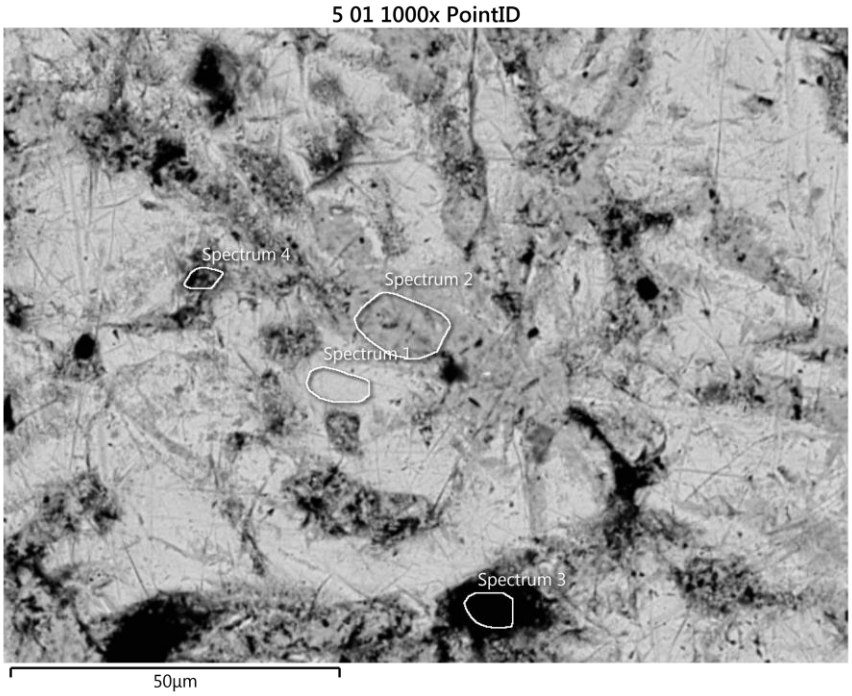


Figure 19. Point & ID Analysis of an Unpolished Area of Specimen #5. 1000X. Monclova 1812 Mexican War of Independence Issue. Ex. Mexican Coin Company. Mexico City 1806 Host Coin. Four Spectrum Areas (i.e., Circled Areas #'s 1-4) were selected by the MSU Analyst.

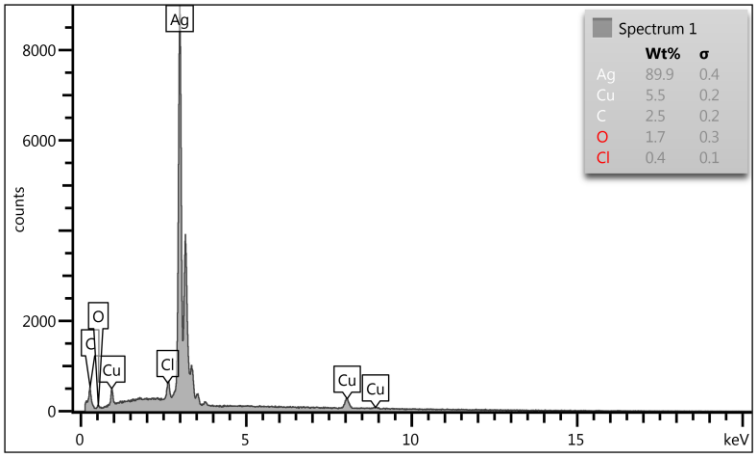


Figure 19-A – In this spectrum area we see a high silver area relating and confirming this high purity of this regal piece near the required ~90% silver assay level. We see 5.5% copper added to give the silver being a soft metal durability and workability in your typical silver/copper alloy of this period. The carbon (C) is primarily from carbonate type compounds found on the surface and the oxygen (O) primarily from oxides such as copper oxide. In SEM/EDS analysis these metals are reported separately (C & O) and not with the actual compounds they form on the coin's surface. Chlorine (Cl) is a typical environmental contaminant. This spectrum area is considered *clean* of surface contaminants. The magnification level of the microstructure is 1000X of the coin's surface.

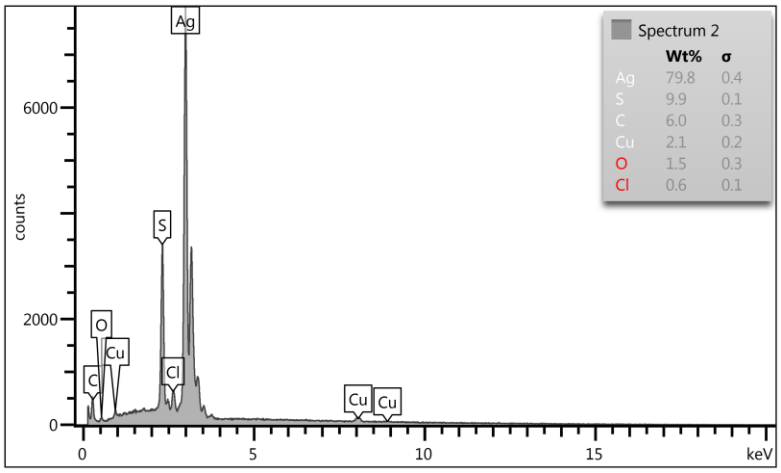


Figure 19-B – In spectrum area #2 of this microstructure micrograph (Figure 19) we see sulfur a common surface contaminant along with chlorine. Sulfur on the surface of an early 19th-century Mexican 8 Reales coin is primarily an environmental contaminant. Over time, silver reacts with sulfur compounds in the air—such as hydrogen sulfide—forming silver sulfide, which appears as tarnish or dark spots on the coin. This process is common in silver objects exposed to air pollution, industrial emissions, or even organic materials like wool and rubber, which can release sulfur compounds.

Additionally, some sulfur may originate from the refining process of the silver itself, though this is less significant compared to environmental exposure. If you're handling one of these coins, proper storage can help slow down the tarnishing process. We see the chlorine present is most likely due to exposure to salt in the atmosphere, particularly in coastal regions. Airborne sodium chloride (NaCl) from seawater can settle on the coin's surface, and over time, moisture can facilitate chemical reactions that introduce chlorine compounds. The presence of both sulfur and chlorine will of course directly raise the levels of carbon (C) and oxygen (O) in the assay as these two metals form carbonate and oxide compounds with sulfur and chlorine as previously discussed. Based on previous studies this author has performed with this method polishing the surface will reduce the level of these outside contaminants on the surface and of course expose more of the coin's original surface. From experience in the 15th-20th centuries we generally always expect to see the two most common surface contaminants sulfur and chlorine to be seen on the coin's surface. Polishing will help reduce the level and give us more of a representative outlook of the true coin's surface at the time it was originally produced.

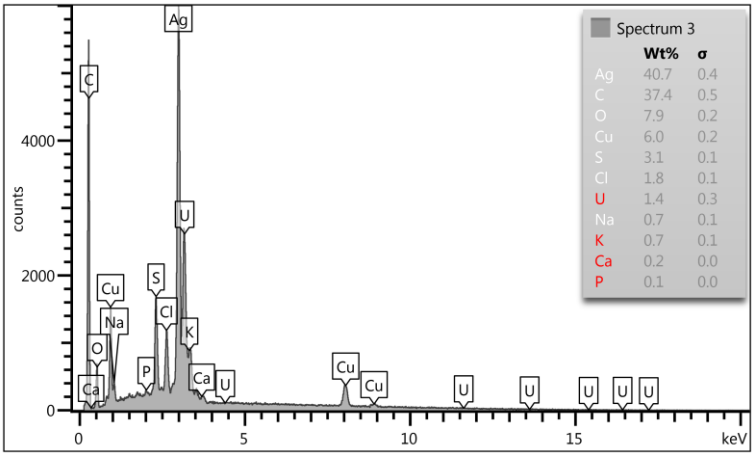


Figure 19-C – This spectrum area #3 of Figure 19 is typical of a surface that has not been polished on a ~90% Ag assay coin. It's over 200-year-old age is quite apparent from all these contaminant metal outliers seen on the surface such as Na, K, Ca & P. In some respects, these large amounts of contaminants confirm the coin's authenticity to the 19th Century to some degree. With these large amounts of contaminants, we also see the C and O values as discussed previously in Figures 19-A & B are also going to increase since with more metals being present this means more carbonate and oxide compounds are present hence the higher C & O values. With this phenomenon note the lowered silver value although at this magnification we will see areas normally either high in silver or high in copper as we target areas of the microstructure which are either silver or copper rich with silver or copper atoms. However, with copper here at 6.0% these other surface contaminant metals are simply making the true original surface of the coin's surface murkier. The unusual presence of U (uranium) is probably a false positive or some strange outlier never seen before by this author. Suffice to say to achieve a representative measurement of this coin's original surface produced in 1812 this spectrum area #3 of this microstructure for this 1812 Monclova specimen is another reason polishing is necessary for meaningful assays when using SEM/EDS analysis with coins that are several hundred years old. In Figure 19-D we see a *similar* case why this is necessary.

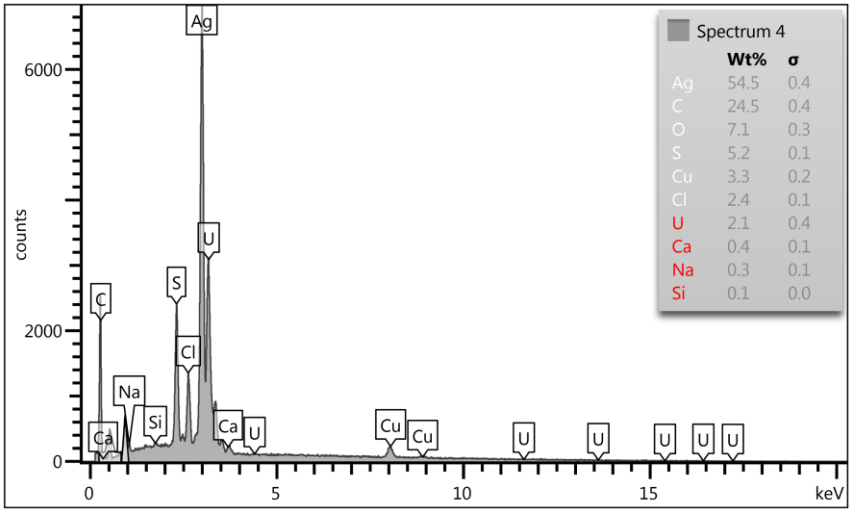


Figure 19-D – We see the same myriads of surface contaminants such as S, CL, U (false positive?), Ca, Na, & Si in Spectrum Area #4. Silicon (Si) found on the surface of a 200-year-old Mexican 8 Reales coin is most likely a surface contaminant. Over time, coins can accumulate environmental residues, and silicon could originate from several sources:

- **Soil and Dust:** If the coin was buried or stored in dusty conditions, it could have picked up silicon-based particles from the environment.
- **Cleaning Agents:** Some past conservation methods involved silica-based compounds, which might have left residues.
- **Industrial Exposure:** If the coin was handled or stored near industrial areas, airborne silicon compounds could have settled on its surface.

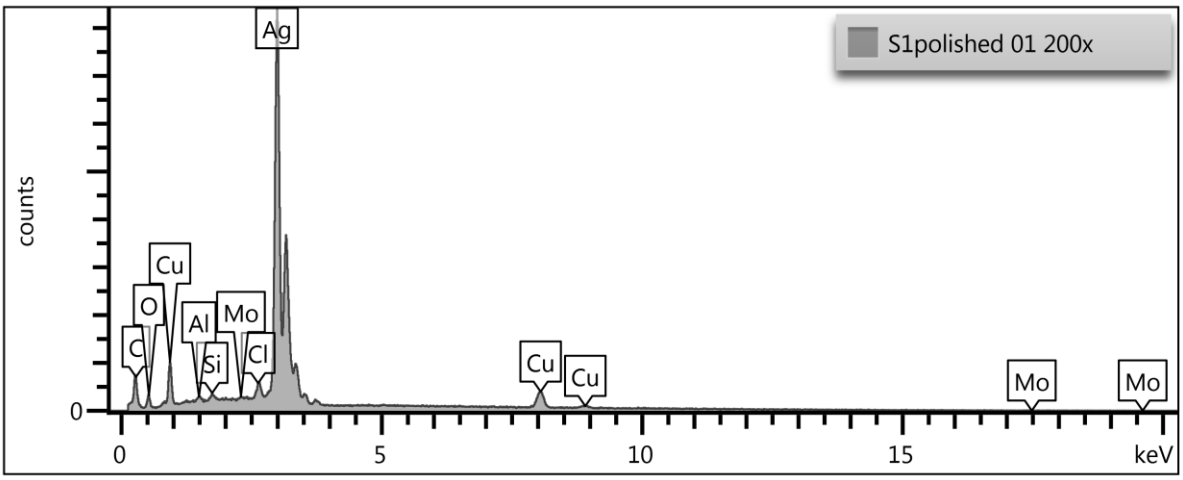
While silicon itself doesn't react significantly to silver, its presence could indicate past handling or environmental exposure. Again, it's unlikely uranium to be present on the surface of an 8 Reales coin as an outside contaminant. Uranium is not commonly found in environments where these coins were stored or circulated. If detected, it could be due to:

- **Environmental exposure**: If the coin was stored near uranium-rich soil or minerals, trace amounts could settle on its surface.
- **Handling contamination**: If someone who worked with uranium handled the coin, microscopic residues could transfer and is unlikely in my opinion.
- **Analytical interference**: Some detection methods, especially X-ray fluorescence (XRF), can produce **false positives** due to overlapping spectral lines with other elements.

Since these results are preliminary and this is an unpolished surface, it will be considered a false positive and unlikely an outside surface contaminant due to an analytical interference reading.

Results of SEM/EDS Analysis of Specimens #1-#5. Polished Edge Areas.

Specimen #1 Analysis: This example has an unusual upside-down applied mint stamp. There is no stop after MVA as seen in Figure 1. It's also required both the MVA and date cartouche should be of "equal size." The host coin is a GNL Class 1 (pre-1830) Contemporary Circulating Counterfeit with a variety # of GNL #1811-O: G/R: Mo HJ-001. Using the triple tier approach, we will discuss each tier separately in the Map Sum Summary/Microstructure Micrograph/Point and ID Analysis within the Microstructure Micrograph.



Element	Line Type	Apparent Concentration	k Ratio	Wt%	Wt% Sigma	Standard Label	Factory Standard
C	K series	0.38	0.00378	5.16	0.25	C Vit	Yes
O	K series	0.29	0.00096	5.56	0.31	SiO2	Yes
Al	K series	0.04	0.00026	0.38	0.06	Al2O3	Yes
Si	K series	0.04	0.00034	0.37	0.05	SiO2	Yes
Cl	K series	0.03	0.00025	0.18	0.06	NaCl	Yes
Cu	K series	1.17	0.01174	8.27	0.23	Cu	Yes
Mo	L series	0.06	0.00055	0.45	0.15	Mo	Yes
Ag	L series	10.86	0.10856	79.63	0.42	Ag	Yes
Total:				100.00			

Figure 20. Map Sum Summary of Specimen #1. Briggs & Bustos so-called Falsa specimen. To get a more accurate reading of the percentages we factor out the carbon and oxygen and normalize to 89.28 or 100 – 5.16 (carbon value) – 5.56 (oxygen value). Since carbon and oxygen are combined with these other metals such as copper oxide. After normalization we get **silver ~89.19%** (79.63/89.28) & **Cu ~9.26%** (8.27/89.28). Aluminum (Al) is a remnant from the polishing method, chlorine is a surface contaminant, copper is added for alloy hardness and workability and molybdenum is often associated with copper ores as a common ore contaminant. In these analyses no gold was detected probably due to the high detection limit (0.1%), the small sample areas and low penetration depth of the SEM/EDS device as previously discussed compared to XRF.

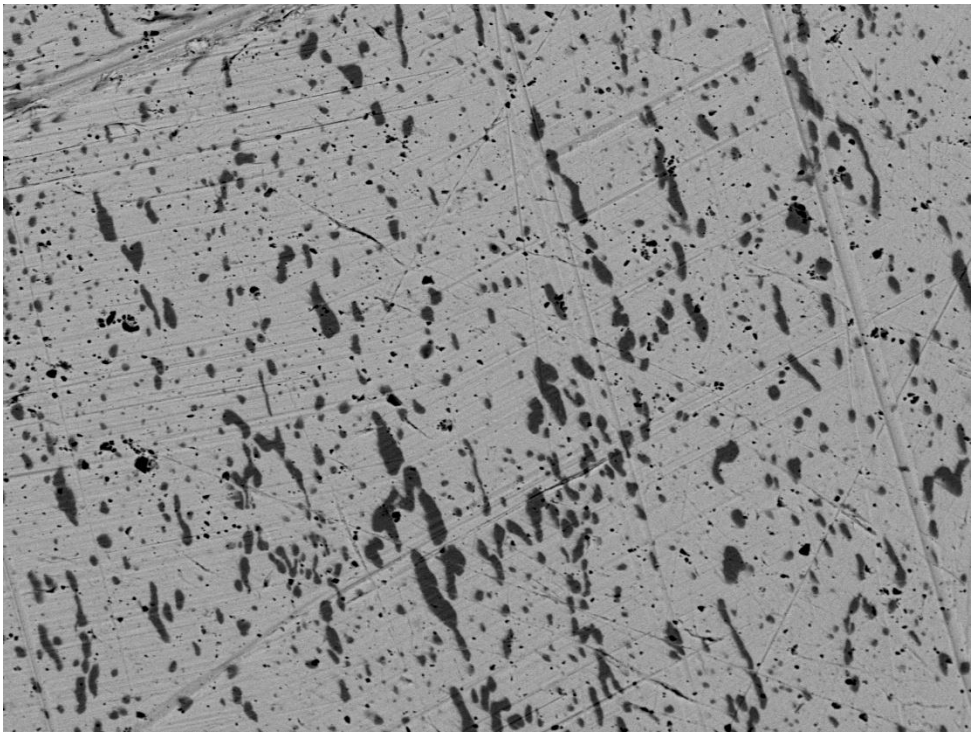


Figure 21. SEM Microstructure Micrograph of Specimen #1. Magnification of Surface: 1000X. As will be seen in the next figure the Point & ID the light-colored areas are silver rich zones and the dark colored areas are silver/copper rich zones. There was a real segregation of silver and copper with little mixing suggesting a cast dendritic microstructure. Based on the microstructure, the copper-rich dendritic structures appear to extend across the material in a rounded or deformed branching pattern. Here's are the observations:

- **Dendritic Growth**: The darker copper-rich regions do not really show interconnected, rounded tree-like formations, which are characteristic of dendritic solidification. These structures form as silver segregates during cooling, creating distinct branches.
- **Phase Segregation**: The darker Ag/Cu-rich areas remain concentrated in specific zones, reinforcing the idea that copper preferentially solidified in different regions.
- **Directional Solidification**: If the dendritic structures follow a particular orientation, it suggests controlled cooling conditions that influence the microstructure's development.
- **Twin Line Features**: If fine linear streaks intersect the dendritic formations, they may indicate twinning effects or a die struck specimen which is the case for this specimen.

The silver level of this is basically regal (89.28%) and it's unusual this piece is not debased silver since it's a cataloged Gurney Class 1 contemporary circulating counterfeit host coin. Was this form of test piece utilized early in the Monclova striking operations? This piece remains an oddity and, in my opinion, still requires further scientific analysis outside the scope of this present study. Let's now look at the Point & ID Analysis of this probable twin-line **die struck** microstructure.

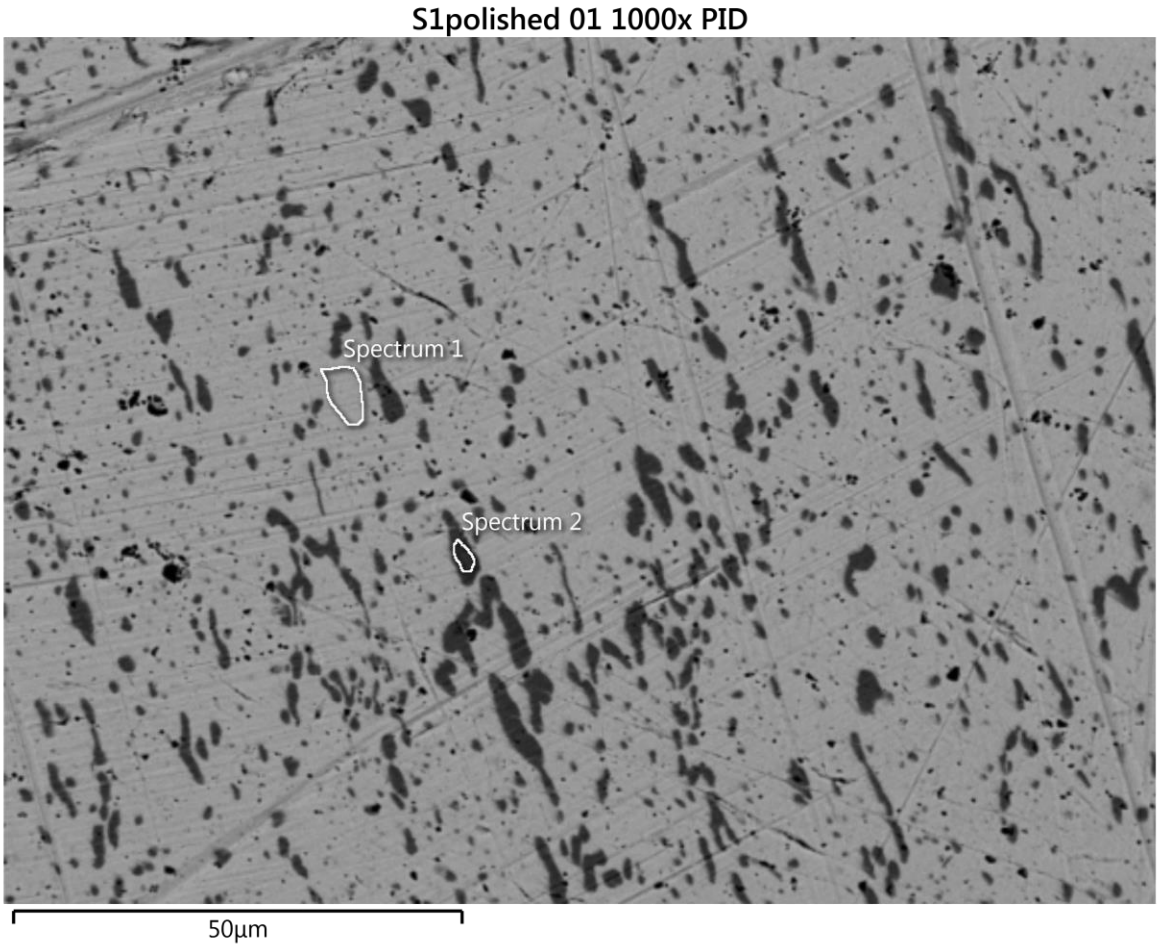


Figure 22. Point & ID Analysis of Specimen #1. Briggs & Bustos so-called Falsa Specimen. The MSU analyst selected a light-colored area which proved to be silver (Ag) rich and a dark colored area which was copper (Cu) rich showing much segregation. Figures 23 and 24 which follow illustrate Spectrums 1 and 2 respectively. Based on the micrograph details and structural patterns visible in the image, this appears to be a **twin line microstructure** rather than a cast dendritic one.

Key Observations:

- **Twin Line Characteristics:** The presence of distinct lines and intersecting features (i.e., jigsaw type pattern) suggests crystallographic twinning which is diagnostic of a die struck piece.
- **Absence of Branching Structures:** Cast dendritic microstructures typically exhibit tree-like growth patterns, but this image lacks significant branching indicative of dendritic cast formations. The coin in hand also does not exhibit any casting diagnostics.
- **Silver and Copper Segregation:** The composition of silver-rich (lighter) and Ag/Cu-rich (darker) areas aligns with twin boundaries, where chemical partitioning can occur.

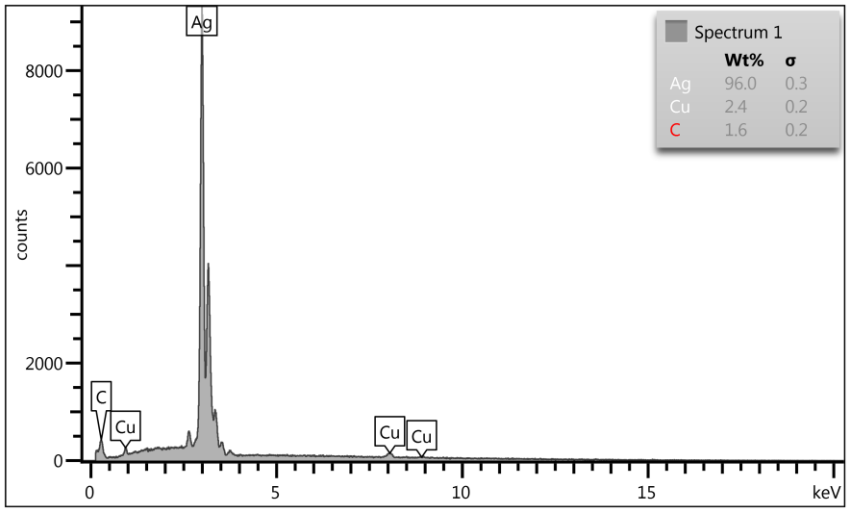


Figure 23. Point & ID Analysis. Spectrum #1. Specimen #1. A rich silver area with silver detected at a level above regal levels (~90%) and yielding 96% silver with some copper detected at 2.4%. The carbon detected forming both silver and copper like copper or silver carbides or carbonates. Note this area is a lighter zone or being silver-rich in its make-up. This will be explained later in this study.

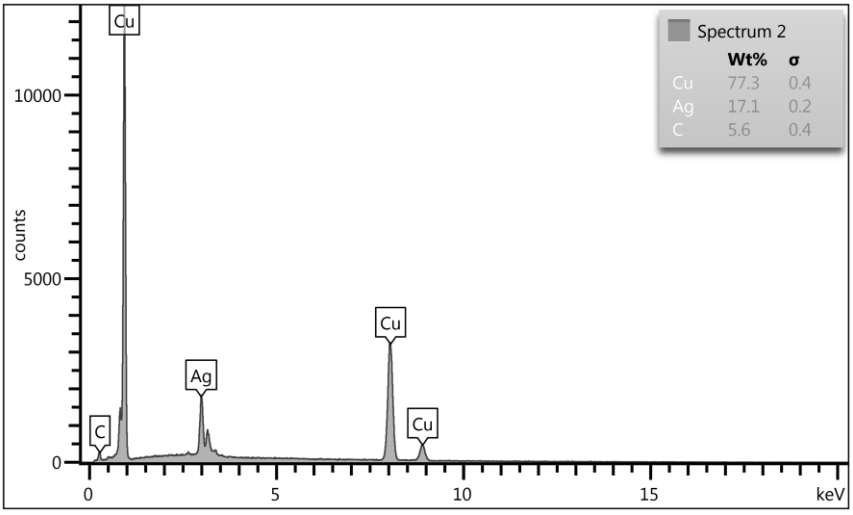
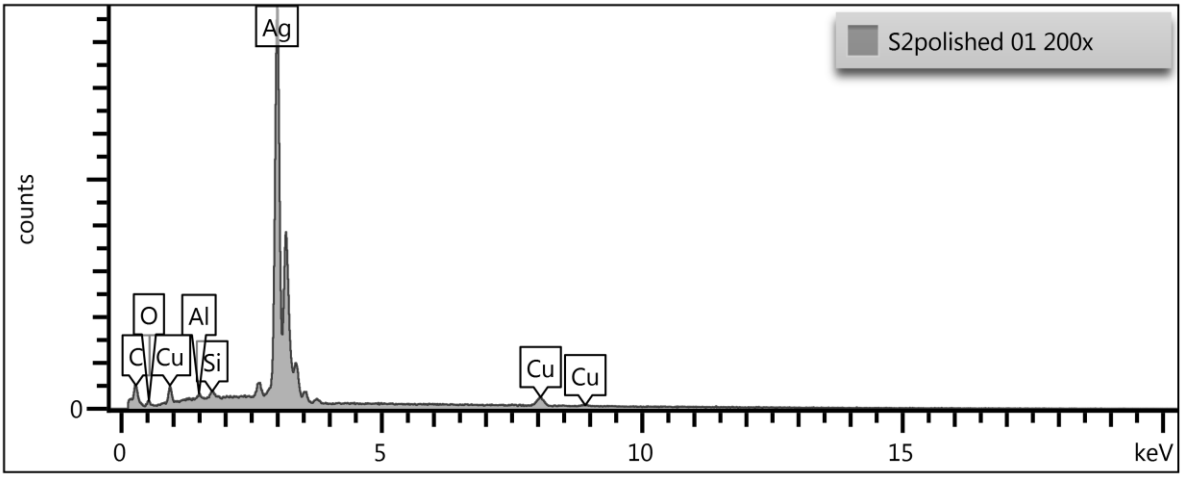


Figure 24. Point & ID Analysis. Spectrum #2. Specimen #1. The dark area of the microstructure predominantly shows copper. In this binary alloy with silver (1763.2*F) melting lower than copper (1984.3*F) copper solidifies first because copper has a higher melting point, it will start forming solid structures before silver does. Silver-rich regions remain liquid longer since silver melts at a lower temperature, the silver-rich areas will solidify **after** the copper-rich portions. Potential dendritic growth depending on cooling rates, copper-rich dendrites will form first, with silver filling in between these solidified structures. As discussed, these dark areas not really showing a dendritic tree-like patterns. This specimen #1 does reflect more twin-line struck characteristics than cast dendritic tree-like patterns.

Overview of Specimen #1: The specimen is a near regal level silver (as verified also by the Briggs & Bustos XRF surface analysis) and its SEM Microstructure profile suggests its struck and not cast. It's a previously reported and listed GNL Class 1 contemporary circulating counterfeit based on its obverse and reverse dies and yet has the diagnostics of a silver regal 8 Reale host coin which is unusual and it's not a debased silver alloy. This was verified by its Map Sum Summary and a Point & ID analysis in a cleaned polished area of the coin's third side removing any surface contamination which may alter its real silver content. Is this coin some form of a test striking piece utilized by these minters at this time and why create such a counterfeit (i.e., falsa) so early as the early 19th Century? It remains a dilemma as it did possibly with Clyde Hubbard and now this collector.

Specimen #2 Analysis: GNL#1809-O:H/R: Mo TH-005. Same GNL variety with the inverted Monclova stamp seen in Gurney's GNL piece. See page 406 in GNL. See Figures 6 & 7.



Element	Line Type	Apparent Concentration	k Ratio	Wt%	Wt% Sigma	Standard Label	Factory Standard
C	K series	0.23	0.00227	2.71	0.20	C Vit	Yes
O	K series	0.14	0.00048	2.91	0.30	SiO2	Yes
Al	K series	0.04	0.00030	0.42	0.07	Al2O3	Yes
Si	K series	0.05	0.00042	0.45	0.06	SiO2	Yes
Cu	K series	0.68	0.00680	4.62	0.20	Cu	Yes
Ag	L series	12.61	0.12607	88.89	0.39	Ag	Yes
Total:				100.00			

Figure 25. Map Sum Summary of Specimen #2. Cast variety of GNL#1809-O:H/R: Mo TH-005. As before we factor out the C&O from100% and it yields 100-5.62%=**94.38% Ag**. This gives a high silver value of 94.2% which is due to silver surface enrichment effects even though the surface was polished from an 88.89/94.38 calculation and **Cu is 4.9%** (4.62/94.38). Aluminum is probably from the abrasive used to polish and silicon is a common surface contaminant or ore processing residue. Although this is a contemporary circulating counterfeit like specimen #1 its interesting its silver value is this high and is not debased with Cu and is like a regal silver 8R issue in its Ag percentage.

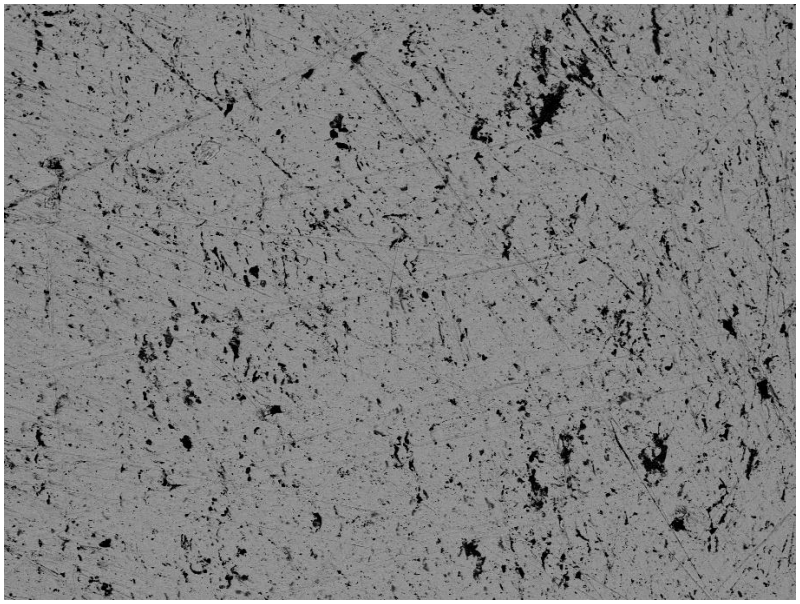


Figure 26. SEM Microstructure Micrograph of Specimen #2. **Magnification: 200X.** Although cast with its blotchy legends and filled-in motifs, the microstructure exhibits some level of tree like dendritic arm branches for the dark colored regions which are Cu rich regions which solidify first in this Ag/Cu binary alloy. This can be caused by several factors. **Key Influencing Factors are:**

1. **Rapid Cooling** – If the alloy cools too quickly, dendritic structures may not fully develop, leading to twinning instead.
2. **High Machining or Surface Processing** – Mechanical stress from machining can introduce twin boundaries, altering the original dendritic structure.
3. **Thermal Cycling** – Repeated heating and cooling can modify grain structures, promoting twinning over dendritic formations.
4. **Mechanical Deformation** – Processes like rolling, forging, or strain hardening can induce twin lines.
5. **Annealing Treatments** – Heat treatments designed to relieve stress can encourage twinning.
6. **Alloy Composition** – Certain elements in the alloy may favor twinning under specific conditions such as silver and copper in this binary alloy.
7. **Segregation Effects** – Heavy elemental segregation can influence grain boundary formation, affecting whether dendritic or twin structures dominate.

This micrograph shows **heavy segregation** suggesting that cooling rates and processing history such as being heavily cold worked played a significant role in shaping the final microstructure (5). We see this effect also in Specimens #3-#5 whose appearance, mint stamps, proper Mexico City host coins are all correct with microstructures which are heavily dendritic (cast) in appearance.

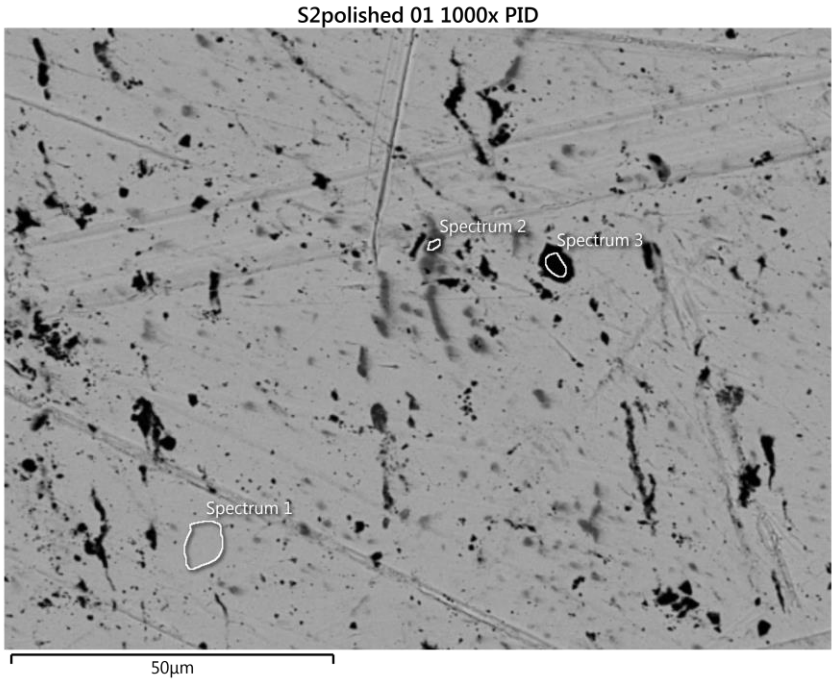


Figure 27. Point & ID Analysis of Specimen #2. Cast variety of GNL#1809-O:H/R: Mo TH-005. In this Point & ID Analysis the MSU Analyst selected three different shaded regions or Spectrum areas labeled Spectrums 1-3. There EDX assays are below in Figures 28-30. These follow the same metal phase segregation pattern seen in Specimen #1 where the lighter region is silver rich (i.e., Spectrum 1) and the darker regions are Cu -rich where Cu is forming first due to its higher melting point forming these somewhat dendritic-deformed branches and the silver fills in the voids around these dark rich Cu areas or the interdendritic regions.

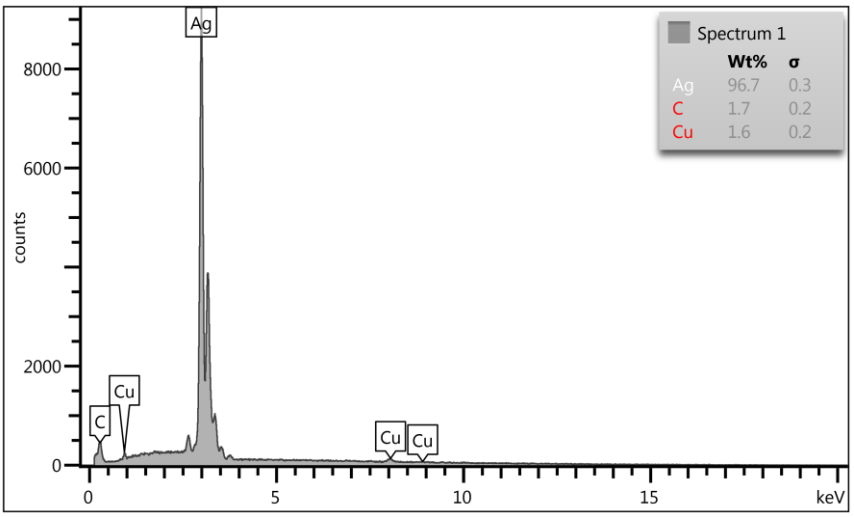


Figure 28. Spectrum #1 of Specimen #2. Cast variety of GNL#1809-O:H/R: Mo TH-005. The light-colored area rich in silver and carbon forming typical carbides/carbonates Ag & Cu type compounds.

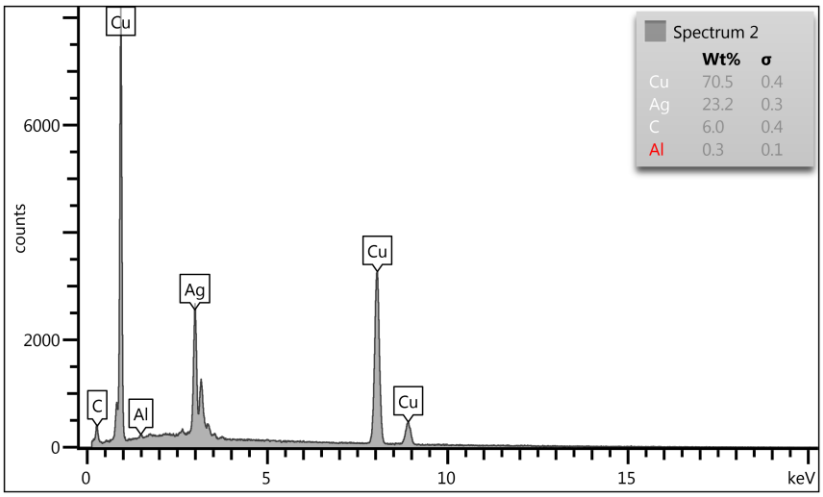


Figure 29. Spectrum #2 of Specimen #2. Cast variety of GNL#1809-O:H/R: Mo TH-005. As previously seen in Specimen #1 the same type of analysis in the darker area, which is Cu-rich (70.5%), silver drastically reduced in these areas (23.2%) as compared to the lighter region of Spectrum 1 at 23.2%. Carbon again forming probable carbides and carbonates with both silver and copper as in Spectrum 1. The aluminum being a surface contaminant and a probable remnant from the polishing process of the third side (edge).

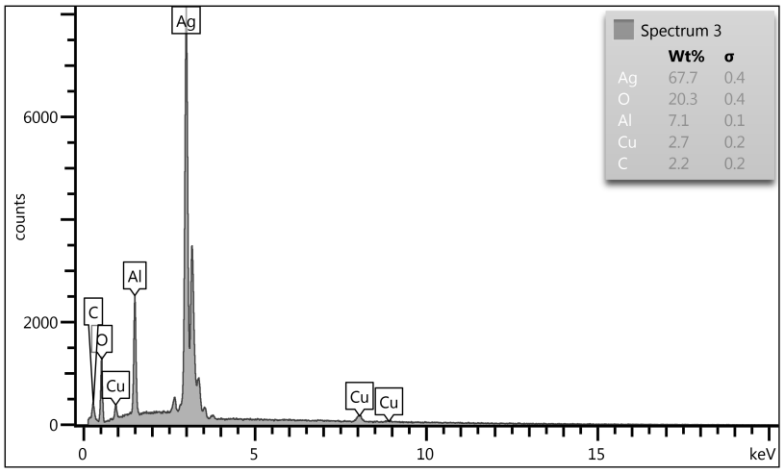
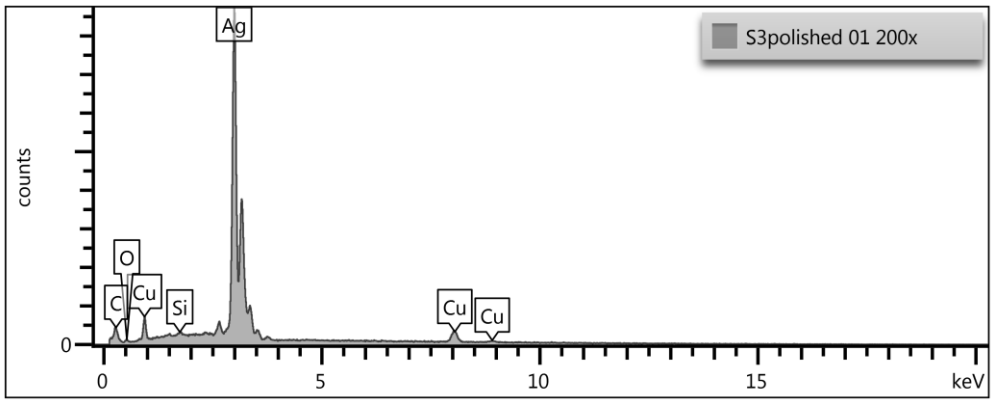


Figure 30. **Spectrum #3 of Specimen #2.** Cast variety of GNL#1809-O:H/R: Mo TH-005. This region shows more silver than copper but oxygen rich with oxides of silver and copper being present. Both silver oxide and copper oxide are black in color, resulting in this dark area.

- **Overview of Specimen #2**: Cast variety of GNL#1809-O:H/R: Mo TH-005: The coin physically in hand based on its appearance as seen in Figures 6 & 7 is the same GNL variety having the inverted MVA and date on the Gurney specimen did show some microstructure profiles of being cast dendritic. This sometimes happens with silver/copper coinage that has undergone rapid cooling and much cold working or surface modifications. This piece exhibited high regal level type silver (~90%) with some silver surface enrichment tendency due to its high reported silver value (94.38% Ag). At times the silver surface enrichment layer on these coins can be thick up to 250 um and in some cases thicker. Again, as with Specimen #1 no gold (Au) was detected but as mentioned SEM/EDS is much different than XRF analysis in terms of the average area of analysis and the penetration depth into the coin coupled with this instrument low detection limit of gold being no more sensitive than 0.1%. SEM/EDS typically has a small field of analysis, often in the range of micrometers, making it ideal for high-resolution, localized elemental analysis. The penetration depth of SEM/EDS is quite shallow—usually a few micrometers or less, depending on the accelerating voltage and the material being analyzed. This makes it excellent for surface-level composition studies. XRF, on the other hand, has a larger field of analysis, often covering millimeters to centimeters, making it more suitable for bulk sample analysis. The penetration depth of XRF is significantly deeper than SEM/EDS, ranging from microns to millimeters, depending on the energy of the X-rays and the sample composition. This allows for subsurface elemental detection. Each technique has its strengths: SEM/EDS excels in high-resolution microanalysis, while XRF is better suited for bulk and subsurface composition studies. If you're working with trace elements or need deeper penetration, XRF can provide better sensitivity and depth. However, in this study the primary goal was to look at the make-up of these coins or their microstructures and to compare how these cast coins were produced. Having said this, with enough SEM/EDS target points the author is certain a target point would eventually show a gold enriched area assuming the 0.1% Instrument Detection Level was sufficient to pick up gold in these over 200-year-old silver artifacts. Looking forward to the microstructure profiles of the three confirmed Monclova specimens (Specimens #3-#5) it was exciting to see how all three microstructure micrographs almost mimic each other or better described as being *mirror images* of each other.

Specimen #3 Analysis. Obverse of the 1804 host 1811 Monclova mint stamp with an LCM stamp which reads from K-2 to K-7 as L.C.M. and was applied later (i.e., over the Monclova mint stamp). My records on this piece indicate there are ~18 different LCM types and this L.C.M. stamp based on vertical and horizontal micrometer measurements and its internal cartouche motifs is identical to a L.C.M. Two Reale Zacatecas-LVO in Pradeau Plate XIX #8 (4). Stops appear after MVA and 1811.



Element	Line Type	Apparent Concentration	k Ratio	Wt%	Wt% Sigma	Standard Label	Factory Standard
C	K series	0.17	0.00168	2.13	0.20	C Vit	Yes
O	K series	0.09	0.00030	1.84	0.27	SiO2	Yes
Si	K series	0.03	0.00022	0.24	0.06	SiO2	Yes
Cu	K series	1.06	0.01059	7.31	0.23	Cu	Yes
Ag	L series	12.29	0.12286	88.48	0.38	Ag	Yes
Total:				100.00			

Figure 31. Map Sum Summary of Specimen #3. L.C.M./Monclova double mint stamp specimen. Incorporating the normalization calculation of the estimated silver and copper values for carbon (2.13%) and oxygen (1.84%) or 3.97% which is subtracted from 100% and we get 96.03%. So, for silver the normalized value is 88.48/96.03 X 100 = **92.1%Ag** and for Cu 7.31/96.03 X 100 = **7.61% Cu.** The Silicon (Si) as described before is a common surface contaminant. At some future point a conventional multi-targeted XRF surface analysis can be performed to search and confirm other metals inherent in these pieces such as Au, Pb and probably Bismuth (Bi).

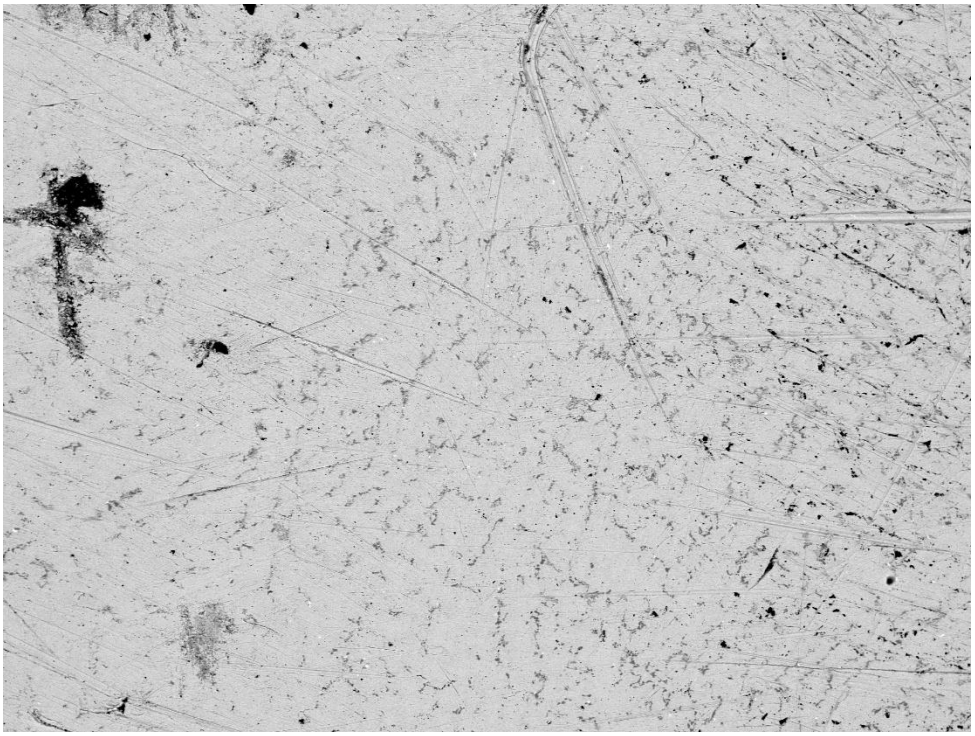


Figure 32. SEM Microstructure Micrograph of Specimen #3 the L.C.M./Monclova double mint stamp specimen. Magnification Level - 200X. The micrograph shows a microstructure with dendritic arms. Dendritic (arm) structures form as the material cools and solidifies, with branches growing in a characteristic tree-like pattern. As in the other specimens #1 and #2 since copper has a higher melting point (1084°C) compared to silver (961°C), it tends to solidify first in the alloy. The dendritic arms you observe are copper-rich, with silver filling in the interdendritic spaces or regions (i.e., outside the dendritic structures) during solidification (see the Glossary of Terms). This process leads to phase segregation (i.e., distinct regions of silver and copper), influencing mechanical properties such as strength and corrosion resistance. In this case the dendritic tree-like patterns unlike in Specimen #2 were not affected. Without a core to surface comparison it cannot really be determined if there was much mechanical cold working or rapid cooling. It's also advantageous when viewing SEM micrographs to acid etch the area but in all cases acid etching was not done again to limit the number of evasive methods to the target area as much as possible and in this case just performing surface etching on the least noticeable area of this costly numismatic artifact - its edge. Acid etching enhances the visibility of microstructural features before scanning electron microscopy (SEM) analysis. By selectively dissolving certain phases or grain boundaries, the technique reveals contrast and texture, making fine details more discernible. This is especially beneficial for metals and alloys where phase segregation or grain structure is critical for analysis. In our case, using *acid etching* on these Ag-Cu alloys before SEM can improve the visibility of dendritic arms and copper-rich vs. silver-rich regions. It helps highlight compositional variations that might be less apparent in an untreated sample. Different acids, such as nitric or phosphoric acid, may be chosen based on the specific material and features you're targeting for less valuable numismatic artifacts in future studies. This microstructure is cast dendritic in nature.

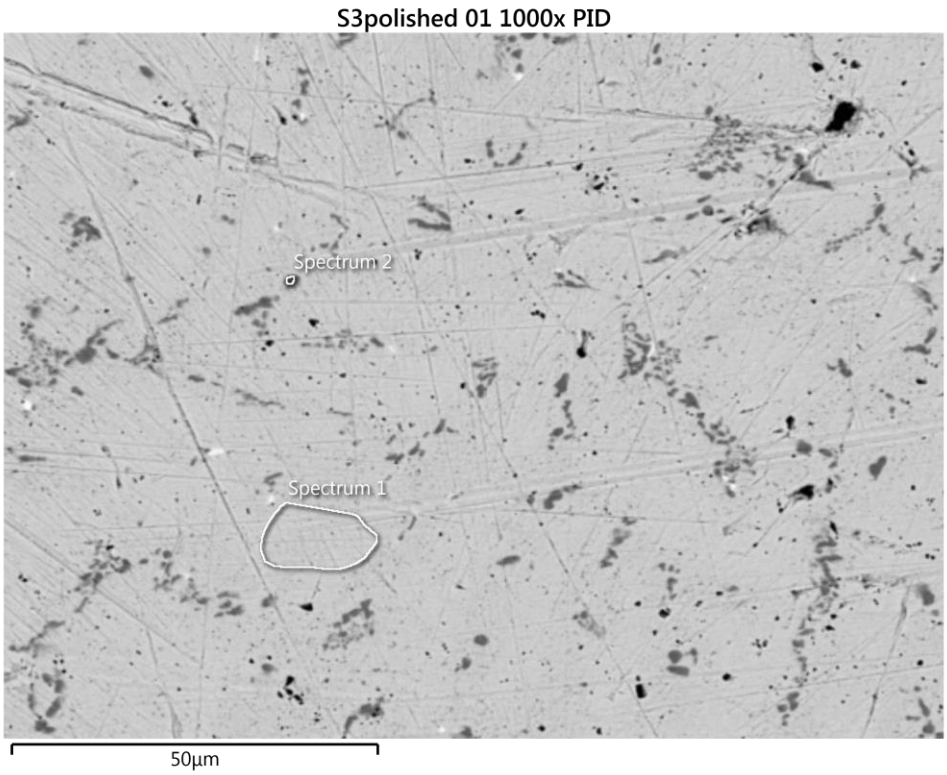


Figure 33. Point & ID Analysis of Specimen #3 the L.C.M./Monclova double mint stamp specimen. As with the other Specimens #1 & 2 in this binary alloy of a Ag/Cu alloy the lighter regions encompass the rich silver areas and the darker regions are predominantly copper as the next two spectrum areas 1 & 2 in Figures 34 & 35 clearly indicate. As mentioned in this cast dendritic microstructure, the tree like Cu rich areas is more well defined and not as disturbed as in Specimen #2 which may have been deformed by surface working or rapid cooling.

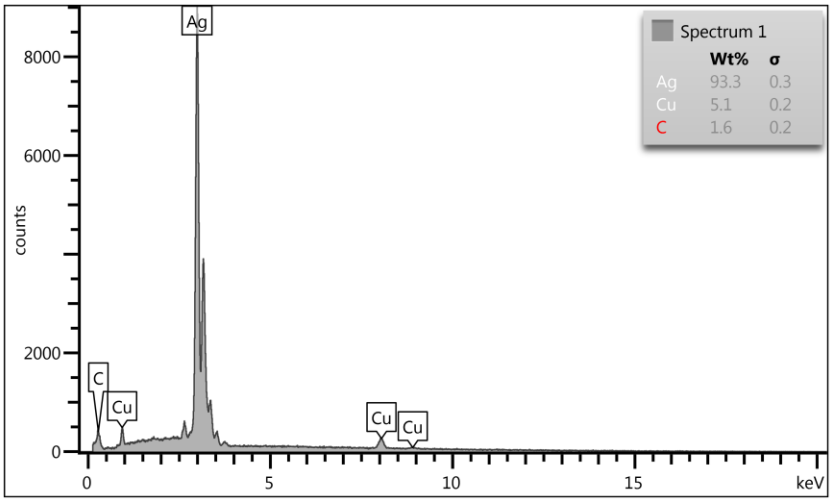


Figure 34. Spectrum 1 area of Specimen #3. See Figure 33. Silver rich area with some copper.

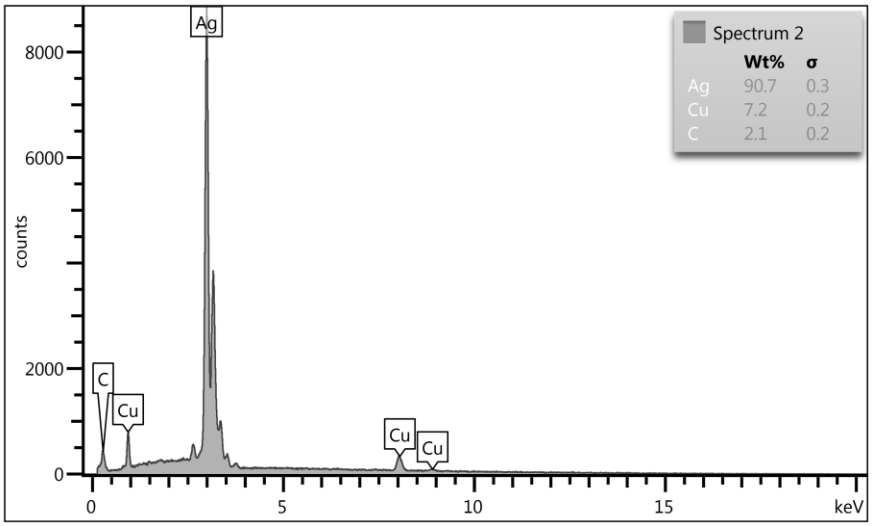


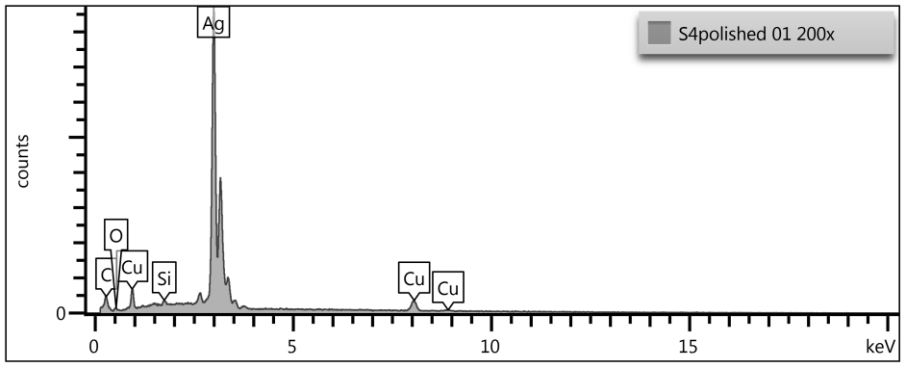
Figure 35. Spectrum 2 area of Specimen #3 the L.C.M./Monclova double mint stamp specimen denoted in Figure 33. The spectrum shows more copper detected than Spectrum 1 area indicating that as with all specimens the darker regions are predominantly copper. Carbon (C) forms carbides and carbonates type compounds with both silver and copper.

Overview of Specimen #3 Analysis: The Map Sum Summary confirms its regal silver level (i.e., ~ 90% Ag level) and the SEM Microstructure (Figure 32) confirms its cast microstructure profile. The dendritic microstructure profile refers to the characteristics and distribution of dendritic formations within a material, typically metals and alloys. Dendrites form during solidification when the molten material cools and crystallizes in a branched, tree-like pattern. The profile typically includes key aspects such as:

- **Primary and secondary dendrite arms** – The main branches and smaller offshoots that grow as solidification progresses. These are the Cu-rich zones in this Ag-Cu binary alloy.
- **Interdendritic regions** – The areas between dendrites that may contain segregated elements, such as silver-rich zones in this Ag-Cu binary alloy.
- **Composition gradient** – Variations in elemental distribution due to phase segregation such as the distinct silver and copper regions seen in the microstructure micrographs.
- **Morphology and spacing** – The shape and spacing of dendritic arms, which influence mechanical properties like strength, ductility, and corrosion resistance.

As a reminder as we move on to specimens #4 & #5 although purchased from reputable auction houses and numismatic dealer sources not all microstructure profiles will display clear dendritic tree like patterns confirming their casting diagnostics. The omission of acid etching does hamper the clarity of the dendritic microstructure as does rapid cooling of the cast planchet and high workability on the surface of these cast planchets let alone from the surface deformations due to being die struck. Luckily this was not the case in this study as all three SEM micrographs illustrated are virtually mirror images of each other for the Monclova genuine Specimens #3-#5.

Specimen #4 Analysis: The 1810 host with a Monclova 1812 mint stamp. Cast Silver. Ex. Aureo & Calico. Previously Marti Hervera of Spain.



Element	Line Type	Apparent Concentration	k Ratio	Wt%	Wt% Sigma	Standard Label	Factory Standard
C	K series	0.19	0.00187	2.34	0.21	C Vit	Yes
O	K series	0.09	0.00029	1.72	0.29	SiO2	Yes
Si	K series	0.06	0.00044	0.47	0.06	SiO2	Yes
Cu	K series	1.11	0.01108	7.43	0.22	Cu	Yes
Ag	L series	12.57	0.12570	88.04	0.39	Ag	Yes
Total:				100.00			

Figure 36. Map Sum Summary of the 1810 host with a Monclova 1812 mint stamp. Cast Silver. Ex. Aureo & Calico. Previously Marti Hervera of Spain. Again, normalizing the Ag and Cu values based on the current C & O values we have 100-4.06= 95.94 and then as with the previous three specimens normalizing the Ag & Cu values to 95.94%, we have 88.04/95.94 X100 = **91.7% Ag** and for Cu 7.43/95.94 X100 = **7.74% Cu**. This equates well with Monclova Specimen #3 result as a cast issue with a regal level silver value near 90%. Silicon (Si) is an outside contaminant from the environment and is not considered an ore contaminant for these binary Ag/Cu alloys.

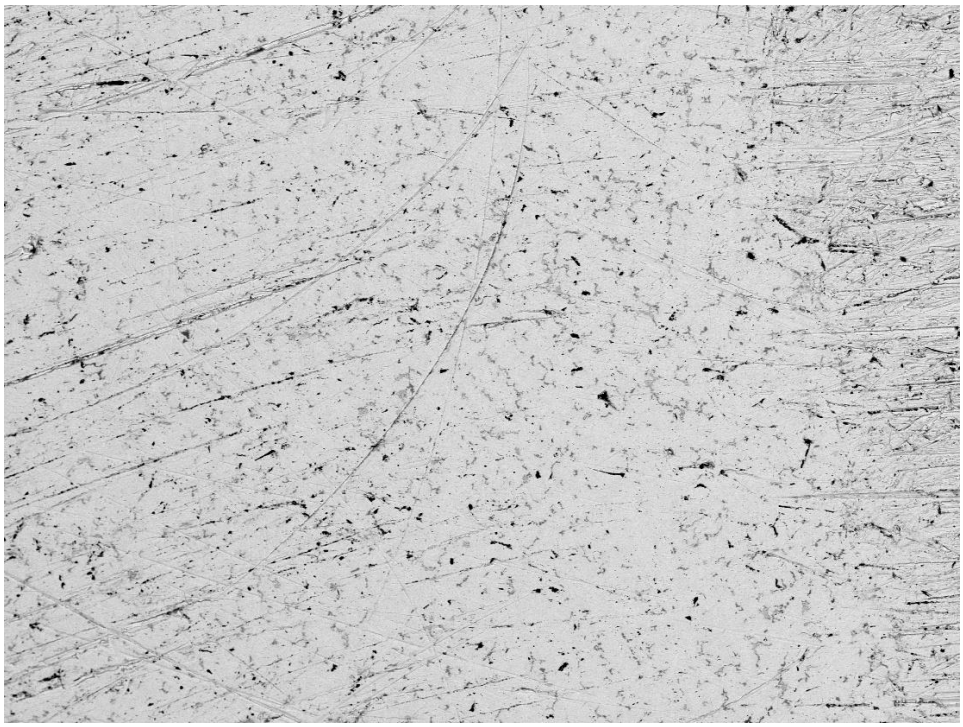


Figure 37. **SEM Microstructure Micrograph** of Specimen #4 the 1810 host with a Monclova 1812 mint stamp. Cast Silver. Ex. Aureo & Calico. Previously Marti Hervera of Spain. Magnification level 200X. Similar micrograph of Specimen #3 the L.C.M. & Monclova double mint stamp specimen illustrating a tree like dendritic microstructure. Compare to Figure 32 where the lighter areas are silver rich and the darker regions are silver/copper rich as will be verified again by Point & ID analysis. As discussed previously **Ag-Rich Areas**: These regions contribute to corrosion resistance and ductility. Silver enhances the alloy's ability to withstand environmental degradation and improves its overall workability. **Cu-Rich Areas**: Copper plays a vital role in strengthening the material. To determine whether the alloy was struck hot directly from casting, you can examine its *dendritic cast microstructure*:

- **Dendrite Fragmentation**: If the coin was struck while still relatively warm, dendrites may appear partially deformed or fragmented rather than fully equiaxed or homogenized.
- **Grain Boundaries & Orientation**: The microstructure might show elongated grains or flow lines if the metal was plastically deformed at a high temperature which is indicative here.
- **Phase Distribution**: A cast microstructure with clear Cu-rich dendrites surrounded by Ag-rich areas suggests minimal mechanical processing. If the dendrites appear broken up or redistributed, secondary processing likely took place before striking which is the case here.
- **Void or Porosity**: If the coin was struck hot from the mold, any residual casting porosity might still be visible, though higher pressure during striking can close smaller voids.

A surface to core of a coin specimen would be required so to verify these points was not possible.

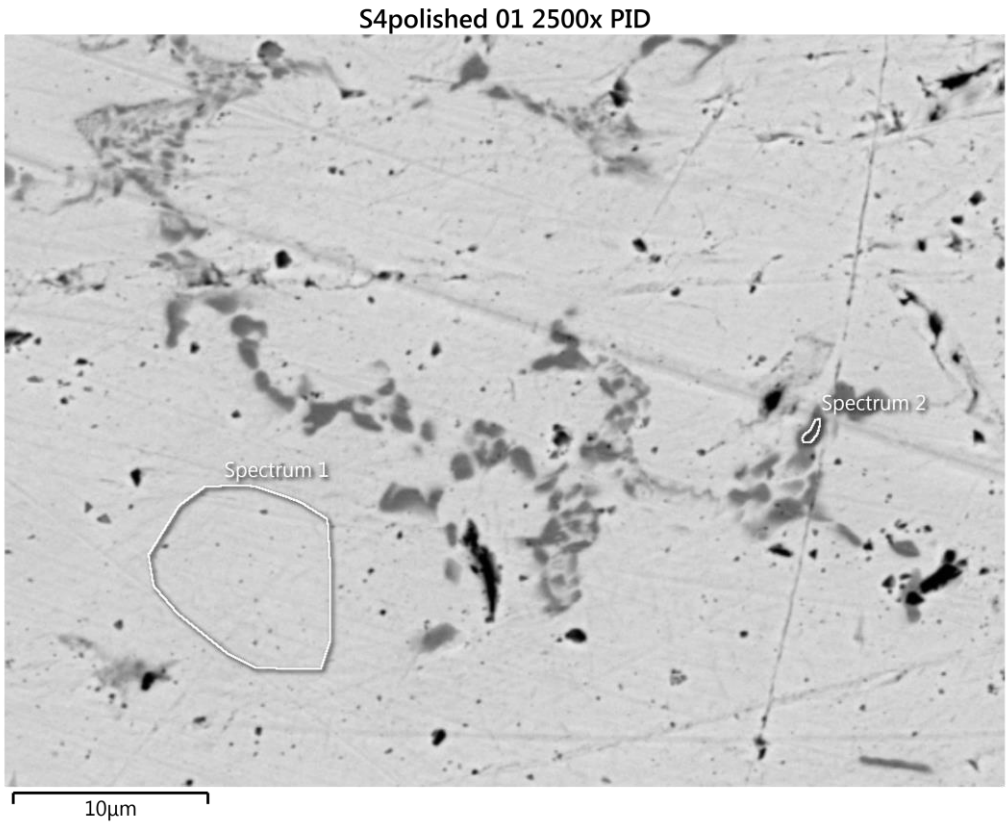


Figure 38 – Point & ID Analysis of Specimen #4 the 1810 host with a Monclova 1812 mint stamp. Cast Silver. Ex. Aureo & Calico. Previously Marti Hervera of Spain. **Magnification: 2,500X**. As with the previous specimens, the light-colored areas are silver rich and the darker regions are silver/copper rich. We verify this in Figures 39 and 40 the Spectrum Areas of Spectrum 1 and 2 noted in this micrograph.

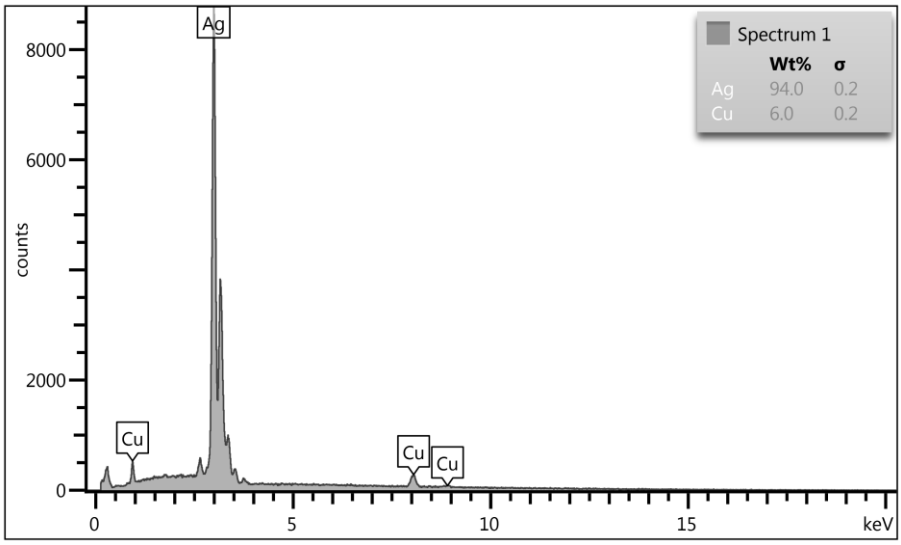


Figure 39 Point & ID Analysis of Specimen #4 the 1810 host with a Monclova 1812 mint stamp. Cast Silver. Ex. Aureo & Calico. Previously Marti Hervera of Spain. Spectrum 1 area seen in Figure 36. The light area contains predominantly all the silver and some copper as previously seen in all the other specimens.

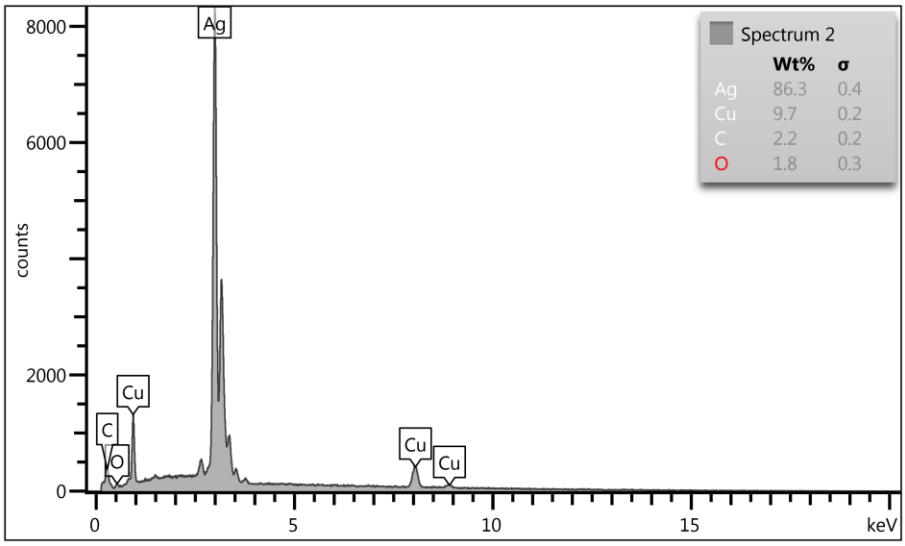


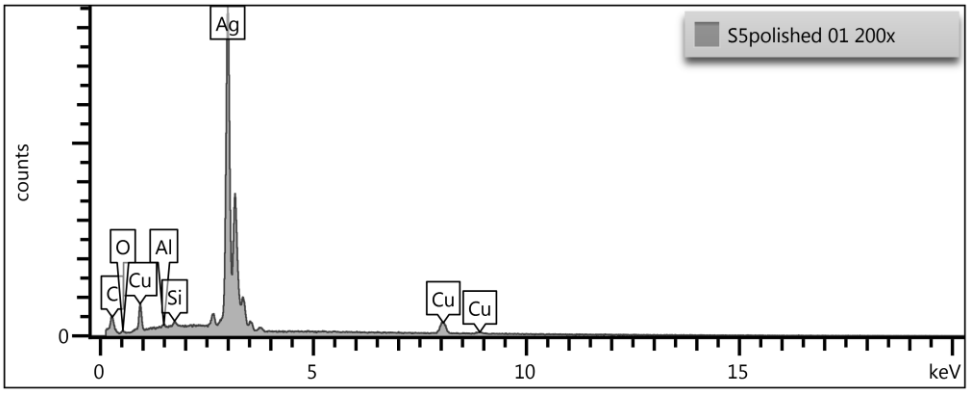
Figure 40. Point & ID Analysis of Specimen #4 the 1810 host with a Monclova 1812 mint stamp. Cast Silver. Ex. Aureo & Calico. Previously Marti Hervera of Spain. Spectrum 2 area seen in Figure 36. The dark area contains a good majority of silver and most of the copper. The carbon forming carbides and carbonates with Ag & Cu and the oxygen (O) forming oxide compounds with the silver and copper as previously discussed. The dark dendritic tree-like branches are the first to form and are the predominant Cu-rich areas.

Overview of Specimen #4 Analysis: The Map Sum Summary confirms its regal silver level (i.e., near a 90% Ag level) and the SEM Microstructure (Figure 31) confirms its cast microstructure profile. The dendritic microstructure profile refers to the characteristics and distribution of dendritic formations within a material, typically metals and alloys. Dendrites form during solidification when the molten material cools and crystallizes in a branched, tree-like pattern. The profile typically includes key aspects such as:

- **Primary and secondary dendrite arms** – The main branches and smaller offshoots that grow as solidification progresses. These are the dark Cu-rich areas.
- **Interdendritic regions** – The areas between dendrites that may contain segregated elements, such as silver-rich zones in the Ag-Cu alloy.
- **Composition gradient** – Variations in elemental distribution due to phase segregation such as the distinct silver and copper regions seen in these microstructure micrographs and verified by Point ID & Analysis in this study.
- **Morphology and spacing** – The shape and spacing of dendritic arms, which influence mechanical properties like strength, ductility, and corrosion resistance.

As a reminder as we move on to specimens #5 although purchased from reputable auction house and numismatic dealer sources not all microstructure profiles will display clear dendritic tree like patterns confirming their casting diagnostics. The omission of acid etching can and often does hamper the clarity of the dendritic microstructure as does rapid cooling of the cast planchet and high workability on the surface of cast mold planchets. In some SEM/EDS this is why coins are frequently sliced in half and core to surface analysis is performed. The advantages include the following: **Elemental Composition Analysis**: SEM/EDS allows for precise identification of the distribution of silver (Ag) and copper (Cu) throughout the coin, revealing whether the alloy composition is uniform or if there are variations between the core and surface. **Detection of Surface Treatments**: Many coins undergo plating, oxidation, or physical diffusion treatment (i.e., exposure to a heat source). By analyzing the cross-section, you can determine if the surface composition differs significantly from the core, indicating possible post-casting modifications. **Microstructural Examination**: The dendritic microstructure of Cu-rich (i.e., dark regions) and Ag-rich regions (i.e., light colored or light gray regions seen in this study) can be studied in detail, helping to assess solidification patterns, grain boundaries, and phase segregation. **Wear and Corrosion Resistance**: Understanding how elements are distributed can provide insights into how the coin will age, corrode, or wear over time, which is crucial for numismatic and metallurgical studies. **Manufacturing Quality Control**: If the coin was struck hot or underwent secondary processing, SEM/EDS can reveal deformation patterns, voids, or inconsistencies in the alloy that might affect durability but only in surface to core studies. The most important point for the reader to consider here is the microstructure micrographs of Specimens #3 & #4 are near identical or mirror images of each other (i.e., Compare Figures 32 & 37) strongly suggesting two coins coming from the same coin production operation!

Specimen #5 Analysis: An 1806 Mexico City cast host coin with a Monclova 1812 mint stamp. This specimen as previously described had good silver and trace gold levels from a previous XRF analysis. In the forthcoming SEM/EDS we will verify its good silver content and view its microstructure to confirm it's of a dendritic (cast) microstructure utilizing SEM/EDS analysis. Ex. Mexican Coin Company.



Element	Line Type	Apparent Concentration	k Ratio	Wt%	Wt% Sigma	Standard Label	Factory Standard
C	K series	0.21	0.00213	2.66	0.22	C Vit	Yes
O	K series	0.09	0.00030	1.74	0.28	SiO2	Yes
Al	K series	0.03	0.00020	0.28	0.07	Al2O3	Yes
Si	K series	0.05	0.00037	0.39	0.06	SiO2	Yes
Cu	K series	1.18	0.01185	7.84	0.23	Cu	Yes
Ag	L series	12.59	0.12594	87.09	0.39	Ag	Yes
Total:				100.00			

Figure 41. Map Sum Summary of Specimen #5 the 1806 host with a Monclova 1812 mint stamp.
Normalizing to 95.6% with the removal of carbon and oxygen weight percentage values from 100% yields 95.6%. So, for Ag we get 87.09/95.6 X100 = **~91.0% Ag** and Cu 7.84/95.6 X 100 = **~8.2% Cu**. These values are more representative of the true silver and copper values on the surface of this Monclova coin. As discussed before, the Silicon (Si) is a surface contaminant and the aluminum (Al) is most likely from the polishing event. As with Specimens #3 & #4 the other Monclova pieces also show a strong regal level type of Ag value near 90% with some degree of silver surface enrichment at this projected silver surface value of ~91.0% Ag. As a reminder we're not seeing lead (Pb), Bismuth (Bi) or gold (Au) since the surface area is smaller than XRF analysis and the penetration depth is much less than an XRF device. So, this instrument SEM/EDS is geared more to determine a coin's microstructure of the metal from which a coin was made so we can comprehend more clearly how they were manufactured.

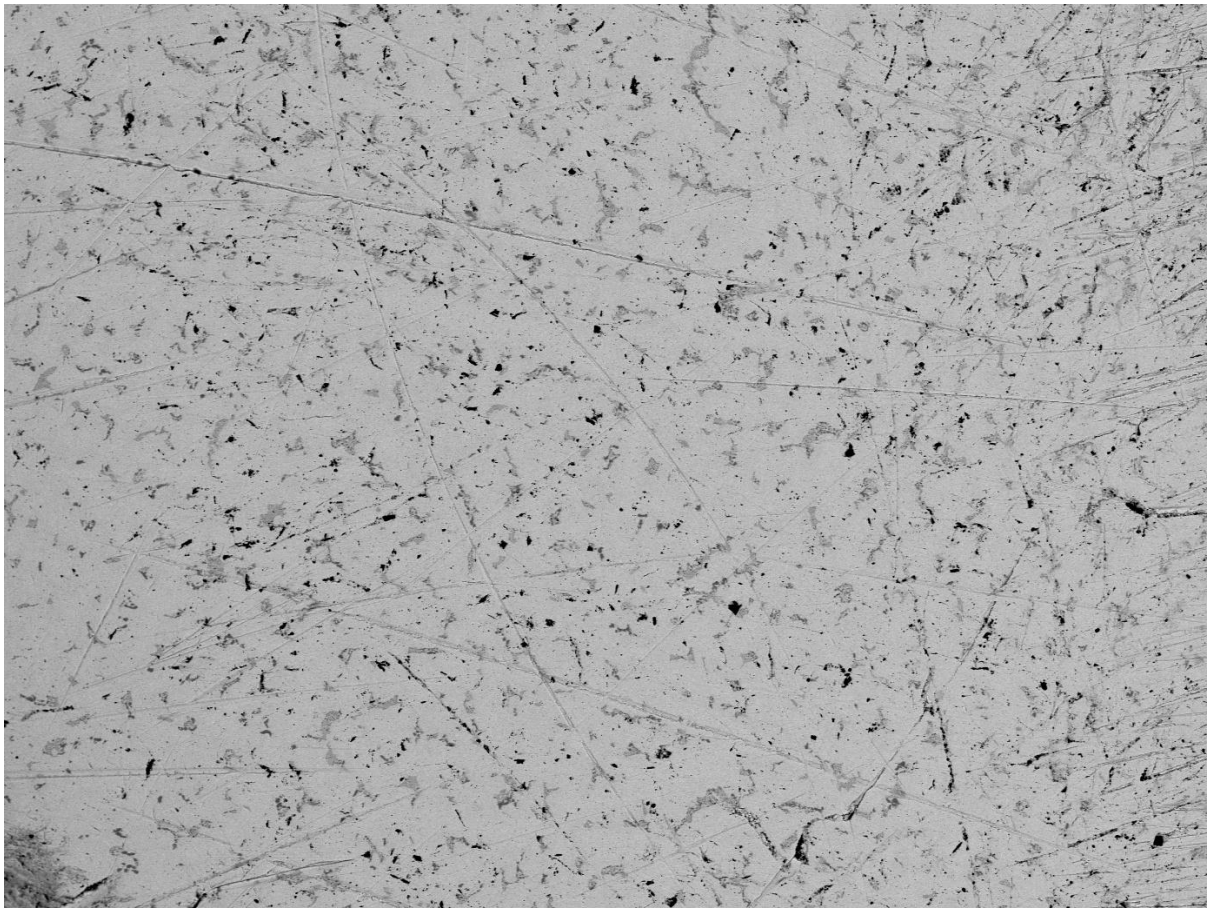


Figure 42. SEM Microstructure Micrograph of Specimen #5 the 1806 host with a Monclova 1812 mint stamp. Cast Silver. Ex. Mexican Coin Company. Magnification level 200X. Similar micrograph of Specimen's #3 & #4 illustrating a tree like dendritic microstructure where the lighter areas are silver rich and the darker regions are silver/copper rich as verified again by the Point & ID analysis. As discussed previously the dark **primary Cu-rich Dendrites** – The first solid phase would be **copper-rich dendrites**, forming a skeletal structure throughout the microstructure. The **silver-rich Interdendritic Regions** as solidification continues, silver segregates into the interdendritic spaces, forming the lighter regions. **Possible Eutectic Structures** – Depending on the cooling rate, there might be fine silver-copper eutectic along the boundaries. **Elemental Segregation & Grain Boundaries** – The grain boundaries could show silver enrichment as Cu solidifies first. It seems from these three examples of Specimen's #3, #4 & #5 the faster the cooling rate the more Cu we would expect to see in the darker regions or putting it another way the more Cu & Ag segregation we will see in the Point & ID analysis between Ag and Cu values when comparing the light and dark regions. In a simpler overview we can see the consistent looking cast microstructure micrographs in this figure as compared in Figure 32 for Specimen #3 and Figure 37 for Specimen #4. All microstructures look similar and Point & ID analyses quantitatively reveal similar separations of Cu and Ag in the light/dark areas suggesting *a common alloy and production process/operation* in their production.

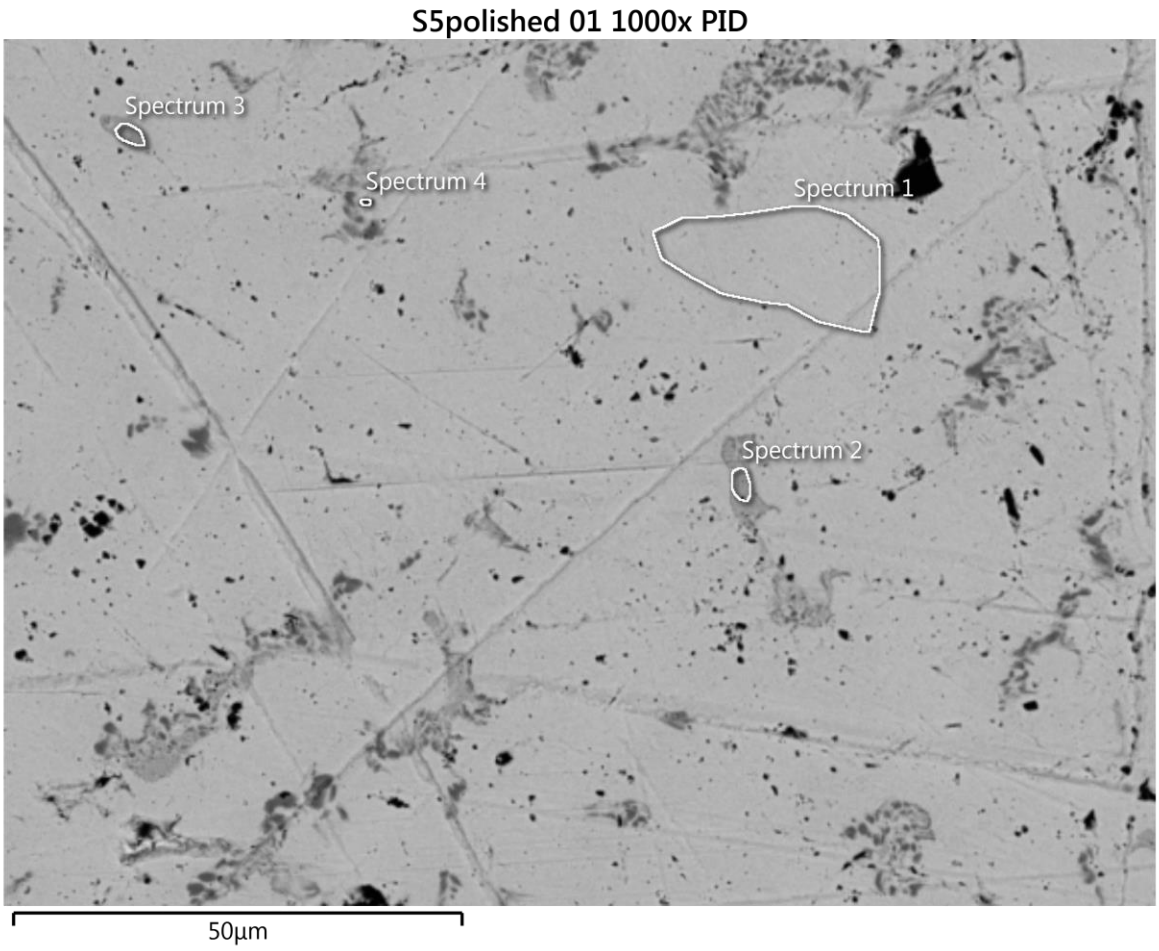


Figure 43– Point & ID Analysis of Specimen #5 the 1806 host with a Monclova 1812 mint stamp. **Magnification: 1000X**. As with the previous specimens, the light-colored areas are silver rich and the darker regions are silver/copper rich. We verify this in Figures 44-47 for Spectrums 1-4 in this Point & ID analysis respectively. Copper solidifies first forming the darker areas, then the silver forming primarily the interdendritic lighter regions and then the eutectic mix (Ag/Cu) areas having the lowest melting point.

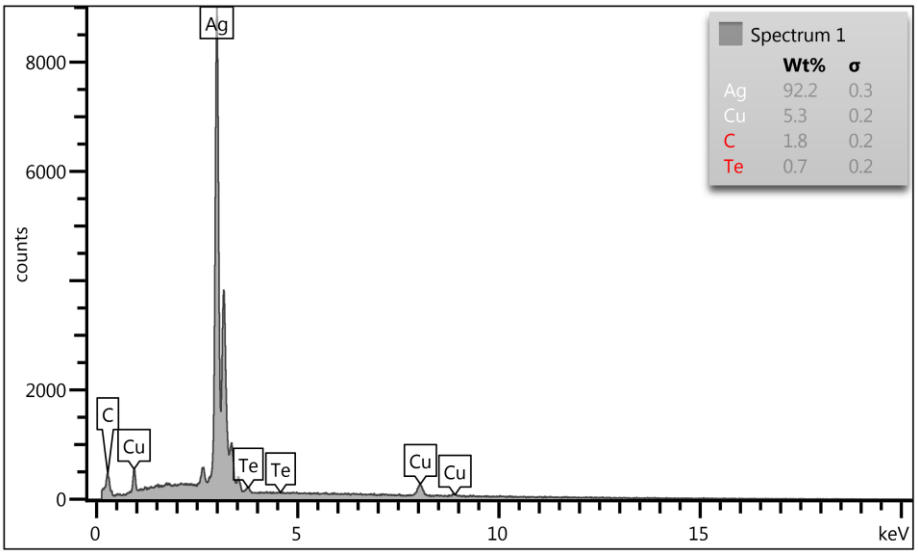


Figure 44. Point & ID Analysis of Specimen #5 (Spectrum Area #1) in Figure 41 the 1806 host with a Monclova 1812 mint stamp. Silver rich area with copper probably incorporating the eutectic mix of silver and copper. Carbon (C) forms carbides and carbonates with silver and copper. The Tellurium (Te) is either a trace contaminant from copper ore refining or it may be a false positive. It's an unusual metal to find and its only presence was in this specimen. It was not found as a surface contaminant in the non-polishing assays of the five specimens let alone Specimen #5 (this specimen) so its occurrence is most likely an ore contaminant. Likely from the presence of copper refining for this alloy and this random target area just happens to reveal its presence.

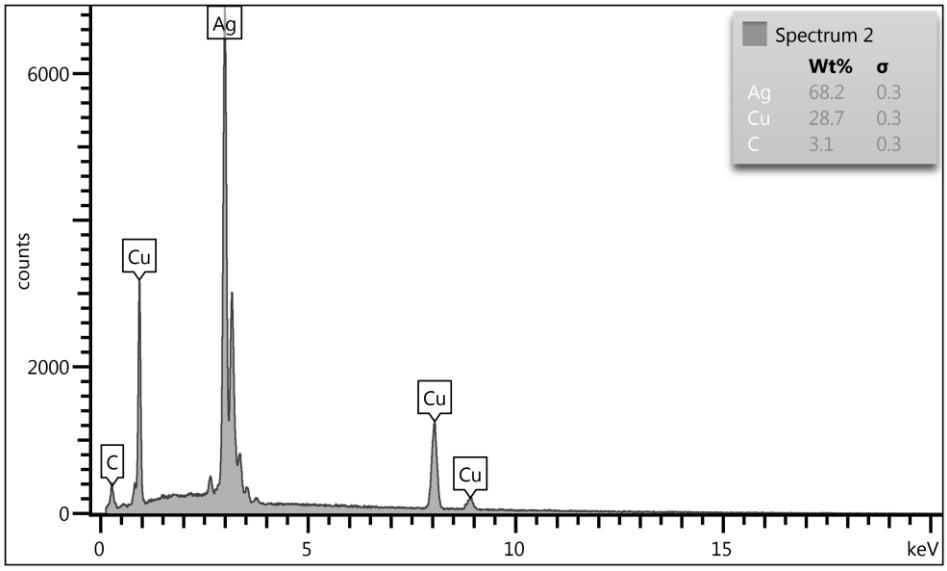


Figure 45. Point & ID Analysis of Specimen #5 (Spectrum Area #2) the 1806 host with a Monclova 1812 mint stamp. With this darker region than Spectrum 1 (Figure 41) we do tend to find as with the other samples to be more copper-rich and we do with a value of 28.7% Cu as compared to Figure 41 (Spectrum 1) with Cu at 5.3%. Carbon (C) forms carbides/carbonates with silver and copper.

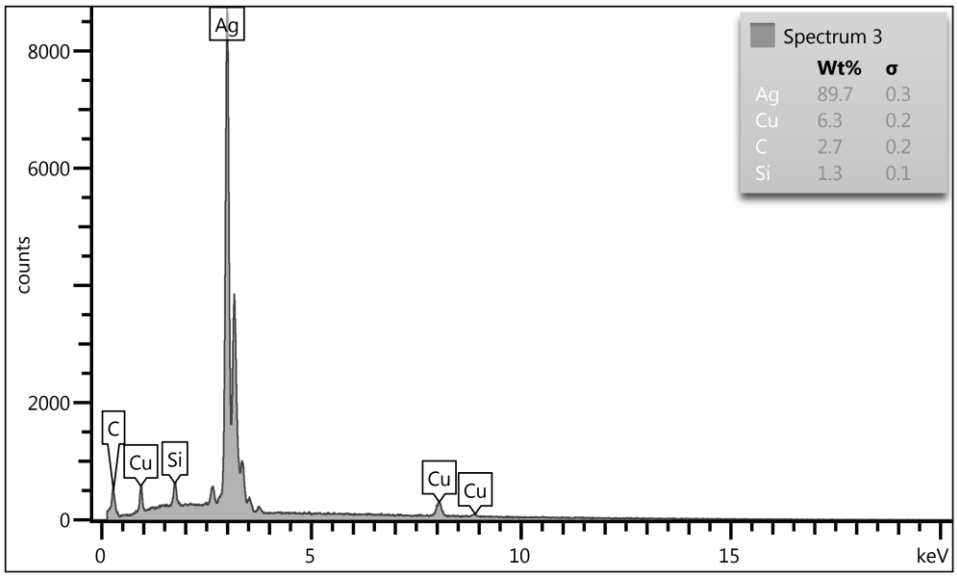


Figure 46. Point & ID Analysis of Specimen #5 (Spectrum Area #3) the 1806 host with a Monclova 1812 mint stamp. Similar to Spectrum #1 with a similar Cu level of 6.3%. Silicon identified before being a surface contaminant and Carbon (C) forms carbides and carbonates with silver and copper.

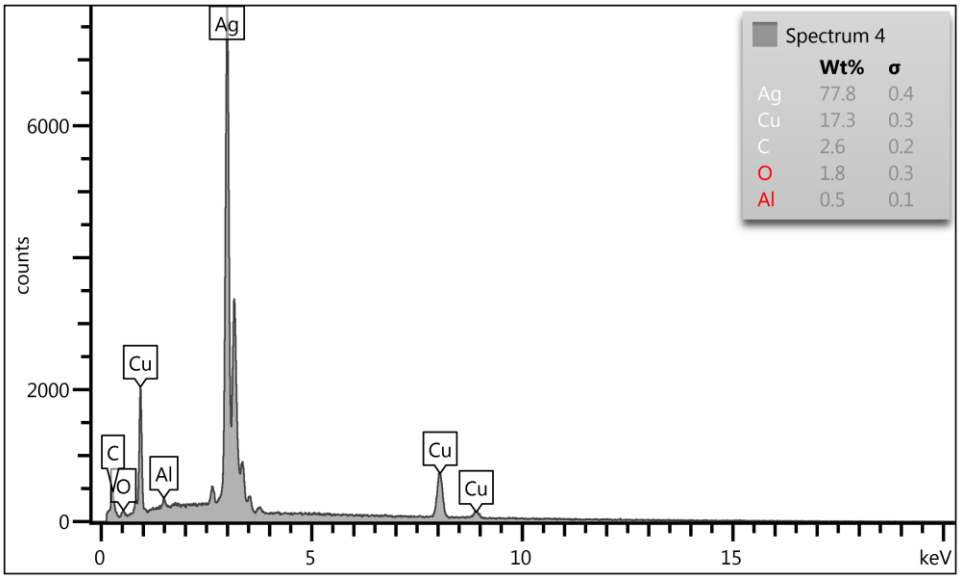


Figure 47. Point & ID Analysis of Specimen #5 (Spectrum Area #4) the 1806 host with a Monclova 1812 mint stamp. A richer copper area (17.3%) with carbon forming carbides and carbonates with Ag & Cu. Oxygen (O) forming oxide compounds with Ag & Cu. Aluminum as a surface contaminant from the polishing event of the edge of the coin by the MSU analyst.

Overview of Specimen #5 Analysis: The Map Sum Summary confirms its regal silver level (i.e., near 90% Ag level) and the SEM Microstructure (Figure 42) confirms its cast microstructure profile. The dendritic microstructure profile refers to the characteristics and distribution of dendritic formations within a material, typically metals and alloys. At this point the author feels a more representative photo is required from a major publication book titled Ancient Metals: Microstructure and Metallurgy – Volume I by David A Scott. In Figure 6.25 he provides an excellent micrograph of a 60% silver/40% copper alloy illustrating a cast microstructure showing the rich darker copper precipitation (i.e., regions) with an infill of eutectic mixture (i.e., silver and copper) seen below in Figure 48. In our examples particularly for Specimens #3-#5 the genuine Monclova pieces as this specimen purchased from the Mexican Coin Company, we confirmed the darker copper rich areas and lighter silver enriched areas with Point & ID analysis. We have also seen eutectic areas with both silver/copper being present. What is the percentage of copper solubility in silver at room temperature and at silver's melting point? At room temperature (25°C), silver can dissolve about 2% copper. As the temperature increases, the solubility of copper in silver also increases. At silver's melting point (960°C), copper and silver form a binary alloy system where they are completely soluble in the liquid state. However, in the solid state, the solubility is more limited, and phase transformations occur depending on the composition. In our study here we see the Cu-rich area forming first or these dendritic tree branch-like areas then the interdendritic region which are silver rich areas. Lastly, then the eutectic regions or the lowest melting point areas also form around these Cu-rich dendritic areas.

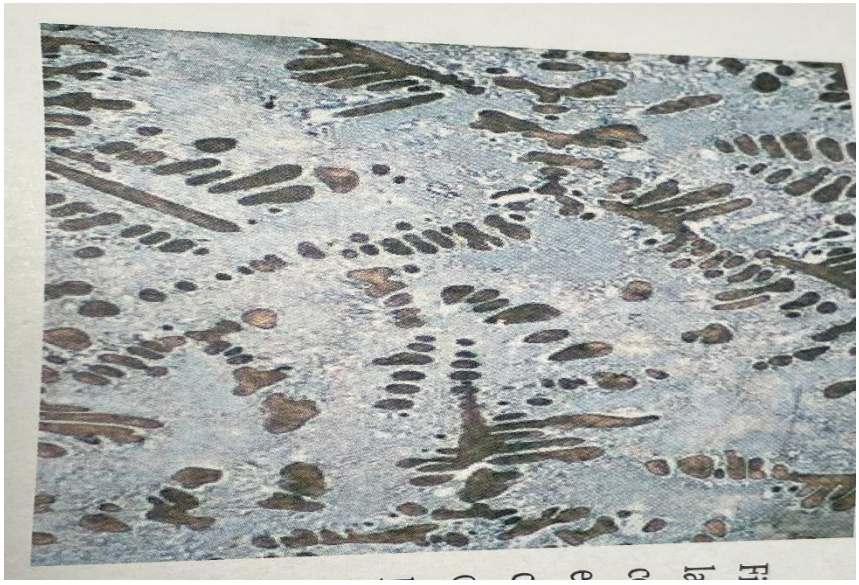


Figure 48 – Photomicrograph: 60% silver/40% copper alloy illustrating a cast microstructure showing the darker copper rich dendrites with an infill of silver (light blue area) and the eutectic mixture (i.e., silver and copper) – light blue area. From J.A. Scott's Microstructure Reference – Figure 6.25 (6). In this case the coin was diamond polished/acid etched/resin color treated prior to SEM analysis. With this clarity the dendritic branch-like Cu-rich arms are very clear and prominent. Once these are formed the interdendritic region (i.e., region around these dark dendrites) infill with Ag/Cu eutectic mix and Ag. Similar to our microstructure micrographs for Specimens #2-#5.

Conclusion: By examining the microstructure of a metal alloy from which a coin was made we can comprehend more clearly how these War of Independence Coins were manufactured. Prior to initiating this study unlike my previous study with this method (3) these coins were worth a lot more as numismatic historical artifacts. Unfortunately, as seen in the unpolished data results on the Briggs & Bustos Specimen #1, as an example, all these coins did exhibit these extra unwanted surface contaminants reported in Figure 18 and Figures 19A-D that surface polishing was minimally required prior to SEM/EDS analysis. In a normal full pre-treatment polishing/acid etching and resin coloring scheme we do achieve the best possible results (refer to the R.A. Scott microstructure – Figure 48). Cutting coins in half and doing surface to core studies is more valuable in terms of differentiating the surface mechanical and environmental changes from die striking, handling and environmental exposure and comparing this to the virgin core area of a coin. These microstructure differences would be obviously more advantageous in determining more information about a coin's manufacturing methods. In any event, the coins were polished yielding greater clarity in their SEM microstructures and much unwanted metals such as Sodium (Na), Potassium (K) and Calcium (Ca) that were surface contaminants were removed from the assays. Additionally, the common environmental contaminants such as Sulfur (S), and Chlorine (Cl) being the two most universally seen and ever present on all coin surfaces were for the most part removed from the Map Sum Summary and Point & ID analyses. As previously mentioned in some ways performing a Map Sum Summary or just a simple XRF surface analysis with a coin in an unpolished state these metals do indirectly tell the analyst the authenticity and older age of a numismatic artifact with these large amounts of so-called garbage metals that have accumulated over two centuries on the surface.

When a pure metal solidifies slowly in a casting mold (and thus cooling is a thermodynamic governed process), a dendritic structure is expected to form, due to thermal supercooling. Dendrites are tree-like structures that form as a metal cool, in a similar way to ice crystals forming as water freezes, in fact, look quite similar (5). The low solubility of copper in silver therefore means a cast silver alloy structure will normally contain a silver-rich solid phase, a copper-rich solid phase and then the silver-copper eutectic phase. The term eutectic is probably best explained by the eutectic point which is the temperature point at which a specific mixture such as a binary alloy of silver and copper will have the lowest possible melting point and in our case is a mixture of 72% silver and 28% copper which has a melting point of 779*C. Therefore, as the metal cools in these Ag/Cu Monclova alloys the last phase to solidify will be the eutectic phase which is why it's always found filling the gaps between the Cu-rich dendritic arms along with the lower melting point silver metal filling mostly in the interdendritic regions. With copper melting at 1085*C and solidifying first followed by silver (961*C) and then the Ag/Cu eutectic mix (779*C) the solidification process proceeds in this left to right order: Cu -first/Ag-second/Eutectic Ag/Cu mix-last. Without doing both surface and subsurface SEM microstructure profiling it was difficult to determine how deformed the dendrites occurred to either being cold worked and/or die struck but nevertheless the cast dendritic (i.e., tree like formations) microstructures were clearly seen in Specimens #2-#5 and the Briggs & Bustos seems to be die struck with a twin line microstructure and surprisingly *not* debased with copper to any degree but of a high silver purity as also confirmed by the Briggs & Bustos XRF surface assay in their catalog description which yielded similar Ag surface values as in this SEM/EDS analysis. At this point we will provide a final specimen overview for reader clarity:

- **Specimen #1:** The original Briggs & Bustos XRF scan had a reported metallic composition via an XRF analysis as follows: Ag (89.81%), Cu (9.89%), Pb (0.19%) & Bi (0.1%). Gold being present will probably be revealed with just more sample points. The Map Sum Summary Ag value seen in Figure 20 of the polished Specimen #1 yielded an almost identical silver value of 89.2% to the XRF scan of Briggs & Bustos. The microstructure appears more die struck or twin line than cast dendritic and the specimen in hand has the visual identifiers as not being cast (i.e., mushy or filled-in motifs). So, it is assumed to be die struck and not cast in a mold. The most surprising thing about the Briggs & Bustos piece is its die struck on a confirmed GNL Class 1 contemporary circulating counterfeit with an estimated period of striking being pre-1830. It's a confusing piece even after this SEM/EDS and Briggs & Bustos XRF surface assays. Why create a forgery on an early 19th century contemporary host and a high silver level host which is a GNL variety normally seen debased in copper or cast? Is this a type of die testing piece used by the Insurgents during this early 19thC period? The microstructure photomicrographs of the other Monclova genuine pieces Specimen's #3-#5 in this study are different than this specimen So, for now Clyde Hubbard's piece seems different than the Monclova genuine pieces and is still a mystery on why it exists? It does not appear to be a later 19th Century forgery based on its current host with its regal level silver value. A perplexing numismatic item.

- **Specimen #2**: GNL #1809-O:H/R: MoTH-005 Class 1 GNL contemporary circulating counterfeit 8 Reale the same die variety as the Gurney piece having the inverted Monclova stamp (GNL page 406). The author's specimen appears as a cast silver coin based on its fabric and has a lower and shorter coin ring than a 90% U.S. Silver dollar. What does it look like compared to a genuine cast silver Monclova mint stamp piece of this same period? This specimen's microstructure was not as definitive as cast dendritic as seen in Specimens #3-#5 the genuine Monclova pieces. It has more dendritic cast characteristics with slightly deformed dendritic branches which were probably the result of heavy cold working and possibly a rapid cooling process. The specimen in hand is obvious to its cast characteristics as seen in Figures 6 & 7 with its blotchy head profile and letter/numeral motifs and filled-in lettering/numerals. A probable heavily reworked and/or cold struck piece and hence having a deformed cast dendritic microstructure with an unusually high silver value particularly for a contemporary counterfeit listed as a Class 1 GNL counterfeit. Some silver surface enrichment is obviously responsible for its elevated silver value of 94.2% seen in its Map Sum Summary (Figure 25).

- **Specimen #3**: An 1804 host Monclova 1811 mint stamp with an LCM later applied validation stamp. Cast silver. For identical MVA/1811 mint stamps with a higher left 'V' and thin '8' in 1811 see both Stacks August ANA 2017 – Lot 22789 & Stacks 1/8/2013 Lot 1545 for identical MVA letter punches and 1811 numeral punches for validation purposes. The Map Sum Summary (Figure 31) confirms its regal silver value (i.e., ~90%) and its microstructure was clearly cast dendritic. The Point & ID Analysis confirmed the Cu-rich dark areas and lighter Ag-rich and eutectic Ag/Cu-rich interdendritic regions around the dendritic branchlike structures seen in the SEM photomicrograph (Figure 32).

- **Specimen #4**: An 1810 host with a Monclova 1812 mint stamp. Cast Silver. Ex. Aureo & Calico. Previously Marti Hervera of Spain. Similar MVA 1812 Monclova mint stamp to Stacks/Bowers November 2012 Auction, Lot 11139 specimen. Map Sum Summary (Figure 36) confirms its regal level silver (i.e., ~90%) and its microstructure was clearly seen as cast dendritic. The Point & ID Analysis confirmed the Cu-rich dark areas and lighter Ag-rich and eutectic Ag/Cu-rich interdendritic regions around the dendritic branchlike structures seen in the SEM photomicrograph (Figure 37). Its SEM microstructure like Specimens #3 & #5.

- **Specimen #5**: An 1806 host with a Monclova 1812 mint stamp. This specimen as previously described had good silver and trace gold levels from a previous XRF analysis. Ex. Mexican Coin Company. The Map Sum Summary (Figure 41) confirms its regal silver value (i.e., ~90%) and its microstructure was clearly cast dendritic and basically identical to Specimens #3 & #4. The Point & ID Analysis confirmed the Cu-rich dark areas and lighter Ag-rich and eutectic Ag/Cu-rich interdendritic regions around the dendritic branchlike structures seen in the SEM photomicrograph (Figure 42).

  As a final notation, this study did have some interesting twists and turns. The Clyde Hubbard piece being a contemporary circulating counterfeit host for this upside-down falsa stamp and is it some form of a die trial piece being so early in its manufacture? What market or collector for these types was going to be enticed to purchase this piece so early in the 19th Century? A fabrication to fool collectors of the same time era as its regal counterparts of 1811-1812? To most collectors, since its host is not cast and this singular punch is distinctly different from its regal counterparts it remains a FALSA and a dilemma to this collector. Were the insurgents so "perfect" in their striking tools and methods? Practices and output of these WOI money species were made primarily for their own military personnel. Specimen #2 being a contemporary cast circulating counterfeit whose microstructure and cast like dendrites seem deformed probably from heavy cold working during its preparation and/or in the manufacturing itself. Some cast microstructure profiles are not so easily confirmed in this alloy primarily when dealing with just the surface of the coin and not a full-scale surface to core investigation. Finally, the three very consistent Monclova genuine pieces (Specimens #3-#5) with all their microstructures virtually being mirror *images of each other,* of the same type of cast dendritic microstructure micrographs, were somewhat expected but nevertheless a pleasant surprise strongly suggesting all originated from a similar manufacturing process.

References

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4. Pradeau, Alberto Francisco. Numismatic History of Mexico from the Pre-Columbian Epoch to 1823. Western Printing Company. Los Angeles California, 1938. Original.
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Glossary of Definitions

Note: Some of these definitions when appropriate were obtained from the Counterfeit Eight Reales (The Un-real Reales) book produced by Robert Gurney, Gord Nichols and this author in 2013 and being sold through Amazon Books. Some other definitions were obtained from my book Forgotten Coins of the North American Colonies – 25th Anniversary also being sold on Amazon Books. The remaining definitions were obtained from the Internet or from Material Analysis books and research papers in my library of other similar Material Analysis numismatic investigations with silver and/or copper alloys.

Cartouche - Refers to decorative frames or borders in various shapes, including rectangles, often used to highlight important text or symbols.

Cast Coin – A coin made by casting liquid metal in a mold which contains the required designs. Cast coins were in fact produced in the period of the War of Independence (WOI) in Mexico. Cast coins are usually produced in a bronze type of alloy but also seen in silver issues with these Mexican WOI issues. Indeed, cast coins are seen as the lowest form of CCC with exceptions such as these highly sought after and prized WOI issues. Cast coins usually have undulations in the fields, air bubbles, vagueness and fuzziness of details in the coin's motifs. The coin's edge may also have file marks which is a finishing type operation to remove the protruding burrs on the edge from the casting mold operation. Using SEM Microscopy in this study SEM photomicrographs were produced illustrating microstructures of cast coins being of a dendritic nebulae pattern seen with all three examples of Monclova cast pieces in this study.

Class 1 Contemporary Circulating Counterfeit – A Gurney/Nichols/Lorenzo (GNL) classification from the Amazon Book - Counterfeit Eight Reales. It's a debased coin produced with reduced silver content, that was made to pass as current money or bullion in various countries without regard to date of production, with a silver assay below 800 fine. A refined definition of the CCC type used in the GNL publication in terms of its silver assay maximum value of 800 fine. Coins in this class are considered approximately made pre-1830 and before as compared to Class 2.

Class 2 Contemporary Circulating Counterfeit – A Gurney/Nichols/Lorenzo (GNL) classification from the Amazon Book – Counterfeit Eight Reales. A coin made predominantly of silver, in various purities which were "near or exceeded standard levels, beginning in about 1830 and ceasing production near 1930. These coins are in other words unauthorized silver imitations which did circulate alongside their genuine counterparts.

Class 3 – Numismatic Forgery – GNL class that describes a coin that was created solely for numismatic purposes, primarily after 1930 solely to defraud collectors of all skill levels. Altered coins are considered Class 4.

Class 4 – Other -GNL class that includes coins and coin-like objects of all types not specifically included in Classes 1-3. It includes all three-dimensional items resembling portrait eight reales regardless of intended use and includes altered coins. Gurney originally believed his 1810 Monclova piece was an altered coin.

Glossary of Terms (continued)

Contemporary Circulating Counterfeit (CCC) – A spurious coin made to circulate alongside originals in day-to-day commerce in the same value, regardless of the same value or design type. In this study the

CCC's analyzed were the Briggs & Bustos upside down Monclova specimen since the host coin was a confirmed GNL #1811-O: G/R: MoHJ-001. The big question was it cast or die struck? The other CCC was an 1809 GNL# 1809-O:H/R: MoTH-005 and this specimen appeared based on its fabric as a cast silver, so it was brought into the analysis and then compared to the three genuine cast Monclova pieces. It was also the variety (1809) that Gurney's piece had the inversion MVA and date.

Counterfeit Coin – A spurious coin used in commerce for the purpose of fraudulent gain. There are two types of counterfeits the desirable CCC's (Contemporary Circulating Counterfeits) such as GNL CCC8R's which are both historic and numismatic worthy and the undesirable modern forgery issues or counterfeit coins like modern Chinese base metal fakes say of a U.S. Federal issue Morgan or Peace Dollars.

Debased Coin – Robert Gurney in his GNL book described as a term used by Riddell in reference to mint made coins of Spanish Republics that failed to meet the standard for silver content in terms of assay and which therefore are fraudulent. Debased coins are treated as genuine by collectors even though they are fraudulent in nature.

Dendritic Cast - A dendrite in metallurgy is a characteristic tree-like structure of crystals growing as the molten metal solidifies, the shape produced by faster growth along energetically favorable crystallographic directions. This dendritic growth has large consequences regarding material properties. In our study the dendritic casts were seen in the genuine Monclova War of Independence Issues, the GNL#1809-O:H/R: Mo TH-005 cast silver contemporary counterfeit the same variety as the Gurney inversion Monclova piece but his host was struck. See GNL page 406. The Briggs & Bustos Clyde Hubbard piece was confirmed as die struck in this study.

Eutectic Structure - A eutectic structure is a homogeneous mixture of two or more substances that solidifies at a single temperature lower than the melting points of its individual components. This occurs at the *eutectic point*, where the liquid phase transforms directly into two solid phases without passing through an intermediate stage. In metallurgy, eutectic alloys are particularly useful because they exhibit distinct melting points, making them ideal for applications like soldering, brazing, and casting. The term "eutectic" comes from Greek, meaning "well melting," highlighting its ability to form a stable solid at a lower temperature. In our study the eutectic Ag/Cu mixture melts lower than both the silver and copper metals individually.

False Positive - A false positive is when a scientist determines something is true when it is false (also called a type I error). A false positive is a "false alarm." A false negative is saying something is false when it is true (also called a type II error).

Glossary of Terms (continued)

Grain Boundary - A grain boundary is the interface between two grains or crystallites in a polycrystalline material. These boundaries are two-dimensional defects in the crystal structure and play a crucial role in determining the material's properties. Grain boundaries can:

- **Reduce electrical and thermal conductivity** by disrupting the orderly arrangement of atoms.
- **Influence mechanical strength**, as smaller grains create more obstacles for dislocation movement, improving hardness.
- **Serve as preferred sites for corrosion** and precipitation of new phases.
- **Affect creep resistance**, which is the material's ability to withstand deformation under prolonged stress.

There are different types of grain boundaries, including **low-angle boundaries** (with slight misorientation) and **high-angle boundaries** (with significant misorientation), each affecting material behavior differently.

Interdendritic Region - The interdendritic region in a microstructure micrograph refers to the area between dendritic arms in a solidified material. During the solidification process, dendrites form as the material cools and the molten phase transitions into a solid. The spaces between these dendrites, known as interdendritic regions, often contain different phases, such as eutectic structures or residual liquid that solidified later.

These regions can significantly influence the material's mechanical properties, corrosion resistance, and overall performance. In alloys, interdendritic areas can be rich in elements that segregate during solidification, affecting strength, hardness, and ductility. Examining these regions in micrographs helps scientists and engineers understand the material's composition and behavior. In our study the dendritic regions or branch like region was the dark zones or copper (Cu)-rich areas and the interdendritic region was the light-colored areas or silver-rich areas. The eutectic regions were regions primarily containing both silver and copper. A simpler way to look at this is silver, copper and the silver/copper eutectic mix all have distinct melting points which solidify at different temperatures and time intervals as the overall Ag/Cu binary alloy mixture cools.

Map Sum Spectra - This map displays the element concentrations of the target elements, sometimes called a "quantitative map". In other words, the metal assay at a particular target point of a coin. In this study a particular random target point chosen by the MSU analyst produced a particular metal assay at that target point. Like a random target point on a coin producing a particular XRF metal assay.

Glossary of Terms (continued)

Mercury Amalgamation Counterfeit – The process of mixing either silver or gold with mercury and spreading this mixture on the surface of the coin followed by annealing. Silver plating is a more sophisticated form of silvering a coin's surface such as Sheffield plating.

Microstructure – Microstructure is the very small-scale structure of a material, defined as the structure of a prepared surface of material as revealed by an optical microscope (i.e., SEM Microscopy) minimally above a 25× magnification level.

Off-Metal – A generic expression used by numismatists to classify a CCC or modern forgery that it's not of a regal nature or a legitimate issue. As an example, a regal legitimate eight reales should be ~90% silver. It's an off-metal CCC if its silver content is not at this approximate silver level such as being debased with a base metal like copper.

Point & ID Analyses – Utilizing a SEM Micrograph certain different shaded regions of black and white were selected for metal assay determination called spectrum areas. In this paper generally the level of 1000X magnification was chosen and different spectrum areas were circled (i.e., identified by the MSU analyst as target areas of analysis) and their metal assays in these regions were reported for each spectrum (i.e., target) area. The spectrum regions selected in a standard Point & ID Analysis normally number in the two (minimally) to four range.

SEM/EDX (EDS) - Scanning Electron Microscopy (SEM) with energy dispersive X-Ray spectrometry (SEM/EDS). Generally classified as an excellent analysis method for cultural heritage type material like coins. The chemical characterization of a coin facilitates the determination of the general provenance and age (i.e., CCC or Modern 20^{th} / 21^{st} century forgery). It also allows its production technology (i.e., cast or struck), intended purpose and the overall authenticity (i.e., regal vs. non-regal). In this study with Michigan State University – Material Analysis Department a triple tier analysis method was utilized: Map Sum Spectrum/SEM Micrograph/Point & ID Spectrum Analyses.

Silver Surface Enrichment – A term which is now commonly used to describe the composition changes which have taken place during the life of a buried or unburied noble metal alloy. In fact, "surface depletion" is a better term, since it seems likely that it is the leaching out of the less chemically stable elements which causes the surface composition to change such as the case of copper leaching out of a high silver/low copper alloy. It should be remembered that silver surface enrichment can also occur with gold/copper alloys and like silver surface enrichment it can be intentional as in applying acid media to the surface or can result from natural corrosion processes over a period. In this study we confirmed elevated silver levels at the surface with various specimens noted in their Map Sum Spectrum summaries for some of these binary Ag/Cu alloys.

Glossary of Terms (continued)

Silver Wash – A chemical or mechanical process used to apply a thin silver coating to a counterfeit coin (CCC) using silver chloride dip or a silver-mercury amalgam paste. The term does not refer to an electro-galvanic or electrodeposited process of deposition of silver as it is much cruder than this method.

Although not as common as gilding or gold wash using mercury it's also seen at times using the same principle as mercury. Mercury has nearly the same affinity for gold and silver to be used in this application method and then generally is followed by some annealing process to burn off the residual mercury which almost always is not successful. This is then easily picked up by surficial XRF analysis done in a vacuum chamber or a SEM/EDS device which always operates in a oxygen free atmosphere vacuum chamber.

Spectrum Areas – In this study the spectrum area were metal assays at a particular target area on a coin's surface. SEM Micrograph spectrum areas were selected for the different shades they exhibit in these Black & White photomicrographs (also termed and abbreviated as micrographs). The different shaded regions indicate different metal or metal alloy regions within the SEM Micrograph. Any area selected by the Point & ID method can be characterized with its metal alloy make-up or the predominant metal in this area. The Map Sum Spectrum is also utilized and is the metal assay at a particular target area of the coin. Both are powerful tools in this three-tier SEM/EDS analysis method in metal alloy assay determinations.

Surface Contaminants – A group of metals found on a coin's unpolished surface originating from environmental air or soil exposure. Two common surface contaminants seen were sulfur (S) and chlorine (Cl) in this study. From previous studies by this author these two contaminants can be considered universally seen on all coin surfaces – it's just a question of what the wt.% will be that is recorded by the Material Analysis instrument such as an SEM/EDS instrument.

Target Area – In this study a random area of the coin's surface that is selected for Map Sum Spectra Analysis. In the spectrum areas within the Point & ID analysis particular areas of the SEM Micrograph are selected as a "target area "based on their different shades of Black & White intensity. So, a target area is a point of analysis which can be random (i.e., Map Sum Spectra) or non-random or analyst selected points as in Point & ID analysis spectrum areas within a microstructure micrograph.

Triple Tier Analytical Method – With each target point at a coin's surface utilizing SEM/EDS analysis a Map Sum Spectra/SEM Micrograph/Point & ID Spectrum Areas are generated with the Map Sum Spectra and Point & ID yielding metal assay results of the coin's alloy and the SEM Micrographs yield information if the coin is cast or die struck based on a coin's microstructure.

Twin (Grain) Line Microstructure – A microstructure seen in struck coins. Either a jigsaw like pattern or slip lines in the form of fine parallel or intersecting lines with slightly curved twin bands. Very different than the dendritic nebulae type microstructure of a cast coin. Sometimes it is also called a twin grain microstructure. Both terms are homogenous.

Glossary of Terms (continued)

X-Ray Fluorescent Testing (XRF) – A non-destructive form of forensic scientific analysis (as is SEM/EDS) of the metallic elements contained in an object using "secondary" fluorescent emissions produced by bombardment with gamma or x-rays. Normally several target areas are recommended for unpolished surface coin areas.

Acknowledgment

The author has been greatly assisted by detailed discussions with Amy Albin and Julie Oesterle of Michigan State University Material Analysis Laboratory. This triple tier analysis method of Map Sum Spectra/SEM Micrograph Magnification Level Imaging/Point ID Spectrum Analysis at a preferred 1000X level where all on their part and their expertise and this triple tier analytical methodology all-encompassing a single target point on each coin's surface. From this analytical approach, the paper evolved with the understanding of the microstructure of the Briggs & Bustos upside down Monclova piece, to the study of a cast silver GNL Class 1 (Pre-1830) CCC8R and finally to a cross comparison of three genuine Mexican War of Independence 1811-1812 Monclova pieces which were used as cast microstructure standards for comparison in this metallurgical study.